BELFAST HEALTH COMMITTEE

REPORT

OF

LOCAL GOVERNMENT BOARD FOR IRELAND

Presented to both Houses of Parliament by command of His Majesty.

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BELFAST HEALTH COMMISSION.

REPORT

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THE LOCAL GOVERNMENT BOARD FOR IRELAND.

CITY AND COUNTY BOROUGH OF BELFAST.

WHEREAS it has been represented to Us, the Local Government Board for Ireland, that the death-rate of the city of Belfast, when compared with that of the majority of the larger cities of the United Kingdom is excessive and that the excess is caused largely hy diseases of the classes which in the present state of sanitary science are known to be preventihle:

AND WHEREAS We, the said Local Government Board, see fit to cause inquiry to he made in relation to the matters represented to Us, as aforesaid, and to other matters connected therewith and concerning the public health in the city of Belfast:

NOW THEREFORE We, the Local Government Board for Ireland, in exercise of the powers given to Us by Section 209 of the Public Health (Ireland) Act, 1878, and of all other powers in this hebalf enabling Us, do hereby appoint

Colonel Thomas Walter Harding, J.P., D.L., formerly Lord Mayor of Leeds, Chairman.

Archibald Kerr Chalmers, M.D., Medical Officer of Health of the city of Glasgow;

Ludovic William Darra Mair, M.D., a Medical Inspector of The Local Government Board;

Peter Chalmers Cowan, M.Inst.C.E., Our Chief Engineering Inspector;

Surgeon-Colonel David Edgar Flinn, F.R.C.S.I., one of Our Medical Inspectors,

to make inquiry and report to Us as to the following matters and things in so far as regards the city of Belfast, that is to say:

1. The cause or causes of the bigh death-rate.
2. The administration hy the several authorities charged therewith of all general Acts and Orders relating to the Public Health and the prevention of disease and of all provisions of local Acts conversant with the same or similar matters, and of all other Acts and Orders, whether general or local, which directly or indirectly affect the public health of the city.
3. The measures they recommend for adoption witb a view to the improvement of the health of the city.

L.S.

Given under Our Seal of Office this Eleventh day of Febraary, in the Year of Our Lord, One Thousand Nine Hundred and Seven.

(Signed),

AUGUSTINE BIRRELL,
H. A. ROBINSON,
T. J. STAFFORD.

BELFAST HEALTH COMMISSION.

REPORT.

TO THE LOCAL GOVERNMENT BOARD FOR IRELAND.

GENTLEMEN,

We have the honour to inform you that we have held an Inquiry at Belfast in accordance with your warrant of appointment, a copy of which is printed on the opposite page.

We held a preliminary meeting at Manchester on the 20th February, 1907, to discuss arrangements and settle the order of procedure. In view of the public interest evinced in the proposed Inquiry, we decided that the sittings of the Commission should be open to the press and the public, and also that evidence should be taken on oath.

On our arrival in Belfast, on the 4th March, we were courteously received by the Lord Mayor, the Earl of Shaftesbury. Two rooms in the City Hall were set apart for the purposes of the Inquiry, and every attention and assistance were given to us by the city authorities, who also undertook to print the daily report of our proceedings.

We held our first public sitting on the 5th March. At the beginning of the proceedings application was made by Mr. W. M. M'Grath, K.C., who, with Mr. H. Hanna, B.L., appeared on behalf of the Corporation of Belfast, and by Mr. A. H. Bates, K.C., on behalf of the Belfast Water Commissioners, that these bodies should be represented by Counsel. Our Chairman explained that the Inquiry was being held for the purpose of ascertaining facts, rather than to try issues between contending parties, and that our opinion was against the admission of Counsel; but, as it might be considered, in view of the serious character of the representations which had led to the Inquiry, that certain bodies were more or less on their trial, and were, therefore, entitled to have their case effectively placed before us, the presence of Counsel would be allowed, subject to the condition that the examination of witnesses should remain in our own hands. This arrangement, which was strictly adhered to, was found to give satisfaction.

Our public sittings, which for the most part were held in alternate weeks, occupied 32 days, terminating on the 24th July; and during that time we received the evidence of 93 witnesses.

On vital statistics relating to Belfast, the Registrar-General for Ireland, Sir Robert Matheson, gave evidence in detail; and afterwards he was good enough to supply us with returns showing the death-rate in the several districts of the City from various causes during the three years, 1900-1902.

With respect to the organisation and administration of the Public Health Department of the Corporation, the following witnesses were examined :—

Mr. Robert Meyer, Acting Town Clerk.
Dr. King Kerr, Chairman of the Public Health Committee.
Dr. Bailie, Medical Superintendent Officer of Health.
Mr. G. Ward, Executive Sanitary Officer.
Mr. R. M'Bride, Superintendent of the House Cleansing Department
Mr. R. Smyth, } Chief Sanitary Sub-Officers.
Mr. W. J. Reid, }
Mr. H. Reynolds, }
Mr. J. W. Macartney, }
Mr. T. Shannon, }
Mr. J. B. Boyd, } Sanitary Sub-Officers.
Mr. J. H. Corry, }
Miss Agnew, }
Mrs. Markland, }
Miss Smith, }
Mr. T. M'Cormick, Port Sanitary Inspector.
Mr. H. P. M'Cann, Inspector of Markets.
Mr. J. A. Jordan, Veterinary Surgeon to the Corporation.
Mr. J. S. M'Bride, Inspector of Cowsheds.
Mr. J. Reynolds, Assistant in Cleansing Department.
Dr. A. Gardner Robb, Superintendent at Purdysburn Fever Hospital (and Workhouse Fever Hospital).
Dr. Osborne, }
Dr. Barron, }
Dr. Coates, }
Dr. Torrens, }
Dr. Milligan, } District Medical Officers of Health.
Dr. Martin, }
Dr. Munn, }
Dr. Manly, }
Miss M'Bride, Inspector of Workshops.
Mr. W. J. Sefton, Lodging House Inspector and Sanitary Sub-Officer.
Mr. J. M'Clatchy, Manager of Corporation Lodging House.
Mr. C. E, Dyer, City Accountant.

In connection with our investigation as to the water supply of Belfast, we received evidence from the following witnesses :—

Professor Lorrain Smith,
Professor Symmers,
Mr. L. L. Macassey, M. Inst. C.E., B.L.,
Mr. F. W. M'Cullough, M. Inst. C.E., Engineer to the Belfast Water Commissioners.
Mr. R. Hamilton, Secretary to the Belfast Water Commissioners.
Dr. A. C. Houston,
Dr. M. H. Gordon,
Professor P. F. Frankland,
Dr. R. Alexander, } Medical Officers of Health, Lisburn Rural District.
Dr. D. P. Gaussen, }
Professor E. A. Letts,
Mr. J. H. H. Swiney, M. Inst. C.E.,
Mr. G. E. Reilly, Superintendent of Waterworks in Woodburn District,
Mr. C. M'Quoid,

and others.

Mr. Bates, K.C., addressed us on the question of the water supply and the evidence given to us on that subject.

With regard to Main Drainage and Sewage Disposal, the following witnesses were heard :—

Mr. H. A. Cutler, M. Inst. C.E., City Surveyor,
Mr. J. Munce, M. Inst. C.E., Assistant Surveyor,
Mr. J. C. Bretland, M. Inst. C.E., formerly City Surveyor,
Mr. W. Redfern Kelly, Engineer to the Harbour Commissioners,
Mr. D. Bennett, Inspector under the Harbour Commissioners,
Professor E. A. Letts,
Mr. J. H. H. Swiney, M. Inst. C.E.,
Mr. R. Patterson, J.P., Member of the Belfast Harbour Commissioners,
Mr. H. F. Gullan, Superintendent of Works for the Corporation,
Mr. J. G. Zachary, Chief Assistant in Works Department,
Mr. W. M'Lean, Engineer,
Mr. H. R. Ross, Factory owner,
Mr. J. A. Hanna, Engineer,
and others.

On the control of the milk supply of Belfast evidence was received from :—

Mr. J. Gregg, Veterinary Surgeon,
Mr. J. S. M'Bride, Inspector of Cowsheds.
Mr. J. A. Jordan, Veterinary Surgeon to the Corporation,
Mr. H. Reynolds, Sanitary Sub-Officer,
Mr. T. Willis, Milk Purveyor.

In relation to the housing of the people, the following witnesses gave evidence :—

Sir Robert M'Connell, Bart., D.L.
Mr. F. Quinn, Contractor.
Mr. J. Downey, Officer of the Citizens' Health Association.
Mr. T. Crozier, }
Mr. H. B. Dunn, }
Mr. A. Maze, } Rent Collectors and House Agents.
Mr. J. G. Holland, }
Mr. W. J. Davison, Sanitary Sub-Officer.

On the arrangements of the Board of Guardians for dealing with sickness and infectious diseases, the witnesses were :—

Mr. J. S. Oswald, J.P., Chairman of the Board of Guardians.
Mr. J. W. Robb, Clerk of the Union.
Dr. J. M'Liesh, Visiting Medical Officer of the Workhouse Infirmary.
Dr. A. Gardner Robb, Medical Officer of the Workhouse Fever Hospital, and Superintendent of Purdysburn Fever Hospital.

On the sanitary condition of the elementary schools in Belfast, evidence was given by :—

Mr. W. Gray, M.R.I.A., Formerly Surveyor under Board of Works.
Mr. P. J. Kelly, Senior Inspector of National Schools.
Prof. J. A. Lindsay,
Dr. Dempsey,
and others.

On the contamination of shell-fish, we received evidence from .—

Prof. E. A. Letts,
Mr. H. M'Cauley, Exporter of shell fish.
Sir Otto Jaffe, Formerly Lord Mayor of Belfast,

and others.

The following members of the Medical Faculty in Belfast were called and gave valuable evidence on housing and general sanitary conditions, the prevalence of phthisis, infectious diseases, the condition of the elementary schools, the water supply, infantile mortality, factory employment, and other matters :—

Sir John Byers, M.D.,
Prof. Lindsay,
Dr. Aicken,
Dr. Dempsey,
Dr. Calwell,
Dr. O'Neill,
Dr. M'Caw,
Dr. Barnett,

And on the same range of subjects evidence was given by :—

Sir Charles Brett,
Mr. J. O'Dempsey, formerly a member of the Corporation.
Mr. H. M'Manus, on behalf of the Trades Council.
Mr. J. Spence,
Mr. J. Duncan,
Miss Galway, Secretary, Textile Operatives Society.

We also had the advantage of several consultations with Mr. Williams, Factory Inspector, whose thorough knowledge of factory conditions in Belfast, and large experience elsewhere, were of the greatest service to us.

Besides hearing evidence, we made personal investigations, in the course of which we visited a number of typical factories and workshops, the Purdysburn Hospital for Infectious Diseases, the Royal Victoria Hospital, the Workhouse Infirmary and Fever Hospital, the Whiteabbey Sanatorium for Consumptives, the Forster-Green Hospital for Consumptives, the Mater Infirmorum Hospital, and the Cripples' Home.

We spent much time in inspecting the housing conditions of the city, especially those of the poorest part of the population, and the sanitary arrangements as to closets, privies, and ashpits, as well as those for the removal and disposal of refuse ; we paid several visits to the refuse depôt in Stewart-street, the refuse destructor, and the tipping grounds within the city, where at the present time ashpit refuse is being used for filling up low-lying sites. In view of the attention which had been called to the filling up of sites in past days, with privy and ashpit refuse, we took the opportunity of visiting such building excavations as were being made in those filled in sites, and caused a couple of excavations, about ten feet deep, to be made on a typical site which was said to have heen so filled in more than ten years ago.

We visited the markets, abattoir, and some retail shops for the sale of meat and other foods ; we inspected a large number of dairies, and also shops where milk is sold in small quantities in the poorer districts, as well as some of the piggeries, of which a considerable number still exist in the City. In view of the doubt which had been frequently expressed as to the purity of the Water Supply, we visited the Stoneyford, Woodburn, and Mourne gathering grounds, as well as the storage reservoirs, the filter beds, and the service reservoirs. Much time was necessarily devoted to the inspection of the sewage outfalls and overflows, to observing the effect of the discharge of sewage upon the waters of Belfast Lough, inspecting the banks exposed at low water, the navigation channel, the development of the sea-weed *ulva latissima*, and the serious nuisance to which the decay of this weed on the shores gives rise at certain seasons.

During the investigation, the Citizens' Health Committee gave us assistance in providing abstracts of the evidence proposed to be given by witnesses on their behalf ; and we wish to express our thanks to the Committee and their Secretary, and also to Mr. Downey, their officer, whose personal inquiries into the housing and sanitary conditions of the City were of considerable service.

Although the Inquiry was not sought by the Corporation of Belfast, or by the Water Commissioners, they received us in a frank and courteous way, gave us most ready assistance, and promptly furnished, often at much trouble, any information, evidence, or documents which were asked for. We think it right to express our special thanks to Mr. Robert Meyer, the Chief Clerk of the Corporation, and to Mr. Hamilton, the Secretary of the Water Commissioners. Our thanks are also due to Mr. Redfern Kelly, the Engineer to the Harbour Commissioners, and to the Chairman and officials of the Board of Guardians.

The work before us proved much more extensive and arduous than anyone had anticipated. It was found to spread over a large part of the administrative work of the city, and to involve the investigation of vital statistics, the incidence of disease, the problems of housing and sanitation, the quality of the water supply and its alleged connection with enteric fever, the control of the food supply, the influence of insanitary schools and factory employment, the causes of flooding, and the special difficulties of Belfast in connection with sewage disposal, the contamination of shellfish, and the growth in the Lough of the weed *ulva latissima*.

The great volume of the evidence which was brought before us has required much time for its due consideration; and the importance of the issues involved has made it necessary for us to deal somewhat fully with many questions in the Report which we now have the honour to submit. For convenience of reference we have divided it into the several sections set forth on the next page, and at section XII. we have brought together a summary of the conclusions and recommendations to which we have been led.

LIST OF SECTIONS.

		PAGE
SECTION 1.—	General Description,	1
2.—	Population,	4
3.—	Vital Statistics,	9
	(*a*) Sources of Information,	9
	(*b*) Death-rate,	11
	(*c*) Causes of Death,	16
	(*d*) Distribution of Deaths as regards age and sex,	20
	Infantile Mortality,	21
	Mortality at other ages,	24
	(*e*) Enteric Fever,	25
	(*f*) Phthisis,	31
	(*g*) Cerebro-Spinal Meningitis,	37
4.—	Water Supply,	38
5.—	Main Drainage,	48
6.—	Sewage Disposal.	52
7.—	Sanitary Circumstances and Administration,	66
	Organisation of Public Health Department,	69
	Control of Infectious Diseases,	73
	Sanitary Inspection,	76
	Housing,	77
	Insanitary Areas,	78
	House Cleansing,	79
	Refuse Disposal,	82
8.—	Milk Supply,	84
9.—	Meat Supply,	88
10.—	Schools,	89
11.—	Conditions of Employment,	95
12.—	Summary of Conclusions and Recommendations,	97

ADDENDUM :—

Enteric Fever in Belfast, by Dr. L. W. Darra Mair, . 103

APPENDICES :—

Selected Reports by Drs. Houston and Gordon relating to Water Supply, ... 143

Section I.

GENERAL DESCRIPTION.

Belfast, now the most populous city in Ireland, and the eighth city in the United Kingdom in regard to population, is situated near the north-east coast of the Province of Ulster, around the confluence of the River Lagan with Belfast Lough. The Lough is a somewhat narrow arm of the sea about 12 miles in length. The breadth of the Lough at its head is about two miles, and it widens very gradually to some 3½ miles near Carrickfergus, about eight miles from Belfast; but, thereafter it expands more rapidly to its entrance, which is nearly eight miles in width.

The approach to Belfast from the sea through the Lough is impressive, and the navigation channel is available for large ships at all times of the tide. The shores and hills bordering the Lough are studded with residences, and on entering the mouth of the Lagan, or the Victoria Channel, as it is called, great shipbuilding yards come into view, from which some of the largest vessels afloat have been launched. Higher up are the quays, always crowded with steamers, many of which ply daily from Belfast to English and Scottish ports.

The city lies, for the most part, on a flat delta, from which rise lofty hills of picturesque outline. These afford lovely views and healthful walks, and on their lower slopes are the dwellings of the wealthier citizens. There is an excellent system of electric tramways radiating from the centre of the city to the suburbs.

A striking feature of Belfast is the great width of its main thoroughfares, and also of very many of its subsidiary streets. The people are well housed. Most of the houses are occupied each by one family, and nearly every house has its own back yard, although in many of the older streets there is no means of access to it except through the dwelling.

Evidence of the active life and growing prosperity of the city is to be found on all sides—in the crowded streets, busy shops, the large warehouses, the great factories, and the splendid public buildings, including the new City Hall, which, admirably situated in a great square, is among the very finest in the United Kingdom.

Belfast is the home of the flax and linen industry. About 6,000 men and 28,000 women and children are employed in the mills where the flax is prepared and spun; in the sheds where the yarn is woven into fabrics; and in the workshops where these are worked into finished articles. Next in importance is the shipbuilding industry, in which are employed about 15,000 men. There are also engineering shops for the manufacture of textile machinery, and important tobacco factories and distilleries.

The River Lagan and the Lough divide the County of Antrim on the north and west from the County of Down on the south and east; and the city occupies a portion of both these counties. Several bridges over the Lagan connect the Antrim and Down sides of the city.

The present area of the city is 14,716 acres, exclusive of tidal waters; the boundaries having been largely extended in 1897 under the Belfast Corporation Act, 1896. The area then added to the city comprised 9,697 acres, wholly situated within the Belfast Poor Law Union with the exception of a small portion till then within the adjacent Lisburn Union

The Belfast Union, which is co-terminous with the Belfast Superintendent Registration District, has undergone practically no change in its area suice its original formation, except for the small addition above-mentioned, of part of

Lisburn Union, and it includes within its boundaries the City of Belfast and two distinct districts, one situated on the western shores of the river and lough in the County of Antrim, the other on their eastern shores in the County of Down. The former district is under the jurisdiction of the Belfast Rural District Council for sanitary purposes, while the latter is under that of the Castlereagh Rural District Council, with the exception of the town of Holywood, which possesses an Urban District Council. For poor-law purposes these three sanitary districts, together with the city itself, are under the jurisdiction of the Belfast Board of Guardians.

GEOLOGY.

The geology of Belfast and district is fully dealt with in one of the Memoirs of the Geological Survey of Ireland. From this volume* we have selected the following extracts to indicate some of the more prominent geological features of the neighbourhood :—

"The geological structure of the district is very clearly expressed in its physical features. The great escarpment stretching south-westward west of Belfast, which breaks at Cave Hill into mural precipices, marks the eastern edge of the Tertiary Basalts and the underlying Chalk, while the broad trough occupied by Belfast Lough and prolonged inland as the valley of the Lagan is underlain by soft Triassic marls and sandstones, and is bounded again on the east by hilly ground, where the more highly-resistant Silurian and Ordovician slate-rocks rise steeply from beneath the Trias. This eastern hilly ground is interrupted by a transverse hollow running from the head of Belfast Lough to the head of Strangford Lough, which marks the presence of an ancient trough lined with Triassic sandstones. The bold hill of Scrabo, at the north-western margin of Strangford Lough, shows the preservation of a portion of these sandstones by a protective covering of dolerite, probably intrusive.

. . . . . .

"The country to the westward of the great escarpment is usually referred to as the 'basaltic plateau', but the term 'plateau' is not strictly applicable, since the ground reaches its greatest elevation in hills near the escarpment and sinks steadily westward to the depression of Lough Neagh and the valley of the Bann. It would be more correctly described by the term 'cuesta,' adopted by Prof. W. M. Davis for slopes of this character. The highest summits . . . . occur in this tract, viz., Divis Mountain, 1,567 feet; Black Mountain, 1,272 feet; Squires Hill, 1,230 feet; Wolf Hill, 1,210 feet; and Collinward, 1,196 feet.

"Except from some limited hollows near the edge of the escarpment, the drainage of this upland is carried westward in small streams to Lough Neagh.

"At the foot of the escarpment, the Upper Greensand, Lias, and Rhætic-formations are too thin and interrupted to have any effect upon the topography, and are indeed for the most part concealed under land-slipped masses, which are very numerous and extensive on the upper part of the slopes of yielding Triassic marl. The marls give place to Triassic sandstone in the lower eastern part of the depression, and sandstone is the underlying rock over the greater part of the present course of the River Lagan, though usually buried deeply under Glacial Drift.

"The present position of the Lagan has been determined by the surface contours of the Glacial deposits, and in Pre-Glacial times the main drainage of the hollow probably lay to the westward of its present course. Indeed, the drainage system of all the low ground has been very greatly modified by the Glacial deposits, and part of the Lagan valley towards its present mouth has been banked off to form the separate basin of the Blackstaff stream. The Dundonald valley, between Belfast and Strangford Lough, is so choked with Glacial drift that it is impossible, with our present information, to form any opinion as to the character of its Pre-Glacial drainage. At present its waters flow over a floor of drift south-eastward to Strangford Lough, in the Comber River, but the watershed between the two loughs is clearly a 'superficial' feature.

"The flat ground around the head of Belfast Lough, on which the lower central part of the city is built, is a Post-Glacial estuarine delta, mainly accumulated during a time when the sea stood ten to twenty feet higher than at present. This stage is similarly represented by the estuarine flat at the head of Strangford Lough, and is marked on the more open parts of the coast-line by a narrow shelf of Raised Beach.

"The hilly ground which rises on the east above the hollow occupied by the Lagan River and Belfast Lough, is broken into two portions by the above-mentioned Trias-filled valley of Dundonald. The main features of these hills are due to Pre Glacial erosion, but the minor details of their topography are largely the result of Glacial and Post-Glacial agencies. The heaping-up of the boulder-clay into smooth oval 'drumlins,' and the rounding-off of the rocky eminences by the grinding force of ice have given rise to the flowing hummocky contours so characteristic of this ground, while the steep-walled little rock-gorges and deep V-shaped trenches in boulder clay along the present stream-courses represent the effect of Post Glacial erosion.

. . . . . .

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* "The Geology of the country around Belfast," by G. W. Lamplugh, F.G.S.; J. R. Kilroe, A. M'Henry, M.R.I.A.; H. J. Seymour, B.A., F.G.S.; W. B. Wright, B.A.; and H. B. Muff, B.A., F.G.S.

"After the close of the Glacial period the land must have stood relatively higher than at the present day, as proved by the occurrence of "Submerged Peat" and by the channel of the Lagan below Belfast having been excavated to some depth below present sea-level. At a somewhat later time subsidence took place, bringing the sea to a slightly higher level than that which it now holds, with the result that the mouth of the valley was converted into an estuary and choked with a muddy and silty deposit containing marine shells—the "Estuarine Clays" or "sleech" on which the lower part of Belfast stands—while on the more open part of the coast-line a shelf was cut and shore deposits accumulated at 10 to 15 feet above the present high-water mark.

. . . . . .

"The coast-line of the district almost everywhere shows proof, in one form or another, that at a comparatively recent period the land stood 10 to 20 feet lower in relation to the sea-level than at the present day.

. . . . . .

"The Lagan is bordered throughout its course with strips of low-lying alluvial 'bottom-land,' much of which is still within reach of the river-floods. In composition, this alluvium is mainly a fine sandy loam, derived from the sandy and clayey drifts through which the valley is excavated. Similar, but narrower alluvial strips border the west-flowing streams of the basaltic plateau and the stream which flows from Dundonald to Comber. But the broadest tract of fresh water alluvium . . . . . is that which covers the floor of the wet hollow immediatsly to the south westward of Belfast, in the basin drained, in part artificially, by the Blackstaff.

"The material in this case consists of a 'warpy' clay, washed from the Triassic Marls and Boulder Clay of the steep slopes below the great escarpment; it varies from 6 to 10 feet or more in thickness, with fine gravel and streaks of woody peat at the base. From the manner in which the Estuarine Clay runs up into the mouth of this depression and merges into the fresh-water alluvium, we may conclude that the deposition of this alluvium commenced during the period of depression indicated by the Raised Beach and Upper Estuarine Clay; but it must still be in progress, as the hollow is occasionally flooded by muddy torrents from the escarpment, thereby causing much inconvenience and loss in the low-lying parts of Belfast around its mouth.

. . . . . .

"Around the head of Belfast Lough large tracts of the low flat shore have been reclaimed from the sea by artificial means in recent times, and this work is still in full progress. On this reclaimed land some of the most important shipyards and other industrial enterprises of Belfast are situated."

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Section II.

POPULATION.

The growth of the city of Belfast has been remarkably rapid. In the space of fifty years the population has more than quadrupled. Its Census populations since 1851 are as follows :—

		Percentage intercensal increase.
1851, - -	87,062	----
1861, - -	121,602	40
1871, - -	174,412	43
1881, - -	208,122	19
1891, - -	255,950	23
1901, - -	349,180	36

The population in 1891 on the area of the city as constituted in 1901 was 273,184 ; the real percentage increase in the latter decennium was therefore 28.

These returns show that the rate of increase between the several Census periods has been very irregular, having ranged from 19 per cent. in 1871-1881 to 43 per cent. in 1861–1871.

A return, handed in by Mr. Munce, Assistant City Surveyor, of the number of new buildings erected in Belfast in every year since 1856, appears below, and is of much interest as an indication of the yearly growth of the city. It shows, like the Census figures, that the city grew very rapidly in the sixties. There then seems to have been a relatively slow increase until 1877, when another period of more rapid growth set in, which was maintained for a few years. This came to an end in 1882, and until 1888 the growth of the city was once again less rapid; but about this time an increase seems to have commenced which continued and grew year by year, particularly after 1892, beyond all the previous records, until it culminated in 1898, when as many as 4,547 new buildings were erected. No doubt many of these were in the newly added area of the city, but the figures of the following years show that the remarkable increase of that year is not to be accounted for wholly in this way. In 1899 and 1900 the number of new buildings showed a large reduction on the record of 1898, and since 1900 increase of houses has been comparatively small. In 1906 the number of new buildings fell to 622, which is lower than that for any previous year since 1860.

Return of New Buildings erected in Belfast annually from 1856 to 1906 inclusive

Year.	No.	Year	No.
1856, ...	176	1882, ...	1,160
1857, ...	251	1883, ...	1,008
1858, ...	403	1884, ...	884
1859, ...	378	1885, ...	1,117
1860, ...	225	1886, ...	1,314
1861, ...	730	1887, ...	1,135
1862, ...	840	1888, ...	1,327
1863, ...	1,455	1889, ...	1,594
1864, ...	1,505	1890, ...	1,996
1865, ...	1,542	1891, ...	2,215
1866, ...	1,160	1892, ...	2,112
1867, ...	1,541	1893, ...	2,533
1868, ...	1,602	1894, ...	2,538
1869, ...	1,660	1895, ...	2,296
1870, ...	1,011	1896, ...	2,917
1871, ...	1,261	1897, ...	3,998
1872, ...	1,047	1898, ...	4,547
1873, ...	823	1899, ...	2,811
1874, ...	869	1900, ...	2,181
1875, ...	979	1901, ...	841
1876, ...	1,101	1902, ...	717
1877, ...	1,158	1903, ...	1,104
1878, ...	1,453	1904, ...	840
1879, ...	1,324	1905, ...	890
1880, ...	1,820	1906, ...	622
1881	1,571		

The present population of the city is somewhat difficult to determine. It is a question which has lately assumed definite importance in consequence of the allegation that the death-rate of Belfast has been excessive as compared with other cities in the United Kingdom, and at the outset of our proceedings there was much conflicting evidence on the point.

If it be assumed that the population has increased since 1901 in the same ratio that was exhibited during the last intercensal period, by the population living within the area of the city as enlarged in 1898, it may be calculated that the population of the city at the middle of 1906, amounted to 397,202 persons.*

If Belfast happened to be located in England, Wales, or Scotland, this figure would constitute the Registrar-General's "estimated" population for the purpose of calculating the official death-rates of the city for 1906. It appears, however, that the Registrar-General for Ireland does not, like his colleagues in Great Britain, estimate the population of communities in Ireland by assuming that the last intercensal ratio of increase or decrease has been maintained. He explained his reasons for not doing so, and informed us that his estimates were framed as the result of consideration of the birth-rate, of the effects of emigration and immigration, and of any local facts of which he could obtain knowledge.

Thus, in the case of Belfast, he estimated for the purpose of preparing his vital statistics, that its population at the middle of 1906 was 366,220 or 31,000 fewer than an estimate framed according to the British method.

The Belfast Corporation contend that this official estimate of the population is too low, and that consequently the vital statistics based upon it are too high. Dr. King Kerr, Chairman of the Public Health Committee, submitted an estimate of his own on which the population in 1906 would be 388,159. This estimate was based in the main on the number of occupied houses in the city, and received corroboration later from Mr. Cutler, the City Surveyor, who arrived at a somewhat similar figure as result of a special inquiry.

In connection with these estimates, both of which are largely based on the number of "empty" houses in 1906 as compared with the number of houses returned as "uninhabited" in the Census of 1901, it has to be borne in mind that the terms "empty houses" and "uninhabited houses" are not synonymous, for the latter term includes business premises unoccupied at night, while the former does not. If allowance could be made for this discrepancy it might well be that both these unofficial estimates would come to be nearly identical with the official estimate of the Registrar-General.

But the Corporation objected to the official estimate not only because, in their view, it was lower than the actual facts warranted, but also on the ground that, if the vital statistics of Belfast are to be compared with those of English and Scottish cities, the estimate of population on which they are based should be arrived at by the same method as that adopted by the Registrars-General for England and Wales, and for Scotland.

There is no doubt much force in this contention, and in view of it two different estimates of population may be utilised; the one, calculated according to the British method, for comparing Belfast mortality with that of English and Scottish cities; and the other, the Irish official estimate, for like comparison with Irish cities.

The difficulty of estimating the population of growing communities in intercensal years is one of very old standing. Probably it will remain a serious difficulty so long as the Census is taken at such infrequent intervals as every ten years. Meanwhile, however, it is without doubt desirable that the whole question of the methods of framing these estimates should be carefully reconsidered by the Registrars-General for the three divisions of the United

* During our sittings, the figure for the population estimated in this way was given as 394,778, but this lower figure is erroneous. In making the calculation referred to in the text, allowance has to be made for increase of population between the end of the first quarter when the Census is taken and the middle of the year, the assumed date of all estimated populations. The figure in the text has been checked in the office of the Registrar-General for England and Wales.

Kingdom, and that, as it is so plainly of advantage to compare the vital statistics of the various communities in these divisions, there should be reasonable uniformity of method in arriving at such estimates. Without some such uniformity it is clear that any useful comparison remains impossible.

The need for this reconsideration is well exemplified by the case of Belfast, for even if it be conceded that the Irish official estimate is too low, there can be very little doubt that an estimate calculated according to the British method is, in the particular instance, too high.

The return of new buildings erected in Belfast, year by year, already referred to, makes it evident, for instance, that the last intercensal increase has not been maintained since 1901; and both Dr. King Kerr's estimate and Mr. Cutler's estimate give like indication.

Calculations based on the birth-rate point also to a diminution of the rate of increase of the population. Thus the birth-rate per 1,000 of Belfast in each of the last four census years was as follows:—

1871	37·5
1881	33·4
1891	33·8
1901	31·1

These figures are based on ascertained census populations and on the number of births actually registered in Belfast as given in the Annual Summaries of the Registrar-General for the years in question; and they indicate that the steady fall of the birth-rate, which has been such a conspicuous feature of nearly all parts of the United Kingdom during the last 30 years, has likewise manifested itself in Belfast.

If it be assumed that the birth-rate has fallen steadily since 1891, and that that fall has continued at the same rate since 1901, it is not a difficult matter to construct a table of estimated population for each year since 1891, based upon the number of births registered each year.

Such a table is set out below, and by way of comparison two other tables are set out showing the population as officially estimated by the Registrar-General for Ireland in each of the years in question, and the estimated population for each year calculated according to the British method, on the assumption that the intercensal increase was uniform throughout the decennium 1891-1900, and has been maintained since. The birth-rates based on these respective estimates are shown in the table in brackets.

TABLE I.—Showing the POPULATION of BELFAST, as estimated in various ways.

Year.	(*a*.) As estimated by the Registrar-General for Ireland.		(*b*.) As estimated by the British Method.		(*c*.) As estimated by the Birth-rate.	
1891	255,922	(33·8)	257,631	(33·6)	255,950	(33·8)
1892	261,046	(32·9)	264,461	(32·5)	256,250	
1893	265,123	(35·5)	271,461	(34·6)	282,500	
1894	269,200	(34·7)	278,634	(33·5)	283,300	
1895	273,277	(35·8)	285,966	(34·2)	298,600	
1896	277,354	(37·4)	293,520	(35·4)	319,800	
1897	281,431	(37·2)	301,242	(34·8)	325,700	
1898	304,610	(36·9)	326,389	(34·4)	352,000	
1899	350,000	(32·7)	334,499	(34·2)	361,000	
1900	359,000	(31·2)	342,811	(32·6)	357,000	
1901	351,083	(30·9)	351,329	(30·9)	349,180	(31·1)
1902	358,680	(30·5)	360 059	(30·8)	360,000	
1903	358,680	(32·0)	369,006	(31·2)	375,500	
1904	358,680	(31·6)	378,175	(29·9)	373,000	
1905	358,680	(31·8)	387,571	(29·4)	378,500	
1906	366,220	(31·0)	397,202	(28·6)	380,500	(29·85)
Quinquennia.						
1891–95	264,920	(34·6)	271,635	(33·7)	275,320	(33·2)
1896–1900	314,479	(34·8)	319,692	(34·1)	343,100	(31·9)
1901–'05	357,161	(31·4)	369,228	(30·4)	367,236	(30·6)
Decennia.						
1891-1900	289,700	(34·8)	295,663	(34·0)	309,210	(32·5)

A prominent feature of this table is that the population figures, as estimated in relation to the number of births, correspond singularly with the main indications of Mr. Munce's table of the number of new buildings annually erected in Belfast, namely, that between the years 1893 and 1899, the population increased very rapidly indeed, and that subsequently this increase was very largely stayed. These figures indicate, indeed, that the population of the city diminished appreciably in 1900 and 1901, and it seems not unlikely that some diminution did in fact take place then, for it is known that a large number of persons (not less than 10,000) left Belfast about that time for war service in South Africa. The disturbing effect of the special growth of the city between 1893 and 1899 is shown in the other two columns of the table; for they indicate that if either of these estimates had been correct, the birth-rate must have risen to over 35 or over 37 about the middle of the decennium, instead of following the almost universal tendency to fall. These high birth-rates, indeed, are almost conclusive proof that the official estimates of the population of Belfast in the "nineties" were considerably less than they should have been.

On the other hand, it is clear from the table that if the population of the city has increased since 1901 in the same ratio as in the last decennium, the birth-rate has fallen at a rate out of proportion to that exhibited in the decennium in question, and although this, of course, is not impossible, it is probably unlikely in an industrial community such as that of Belfast. The Irish official estimate seems to err in the opposite direction, for it appears to require an assumption that the birth-rate has remained stationary since 1901. While this again is not impossible, it is contrary to the general experience, and may be regarded also as somewhat unlikely.

On the whole, therefore, it seems reasonable to assume that the population of Belfast in 1906 was, approximately, that given in the third column, namely, in round figures, not much more than 380,000.

The difficulties of estimating populations for single years may be largely met by dealing rather with groups of years, such as quinquennia and decennia. The table therefore includes the mean annual populations for such groups of years.

For much the same reason there is advantage in dealing with the whole of the Belfast Registration District rather than with Belfast city alone. Moreover, fallacies occasioned by the concentration in Belfast institutions of the sick poor from districts outside Belfast, and difficulties created by alterations of boundaries, tend to disappear by directing attention to the entire registration district. There is additional advantage in doing so, owing to the fact that, in the Annual Reports of the Registrar-General, the mortality returns, having been revised by him, are more accurate than those in the weekly and annual "summaries" dealing with towns, and because the detailed information given therein, until recent years, as to mortality refers only to registration districts. Furthermore, since the same system is followed in England and Wales, it becomes practicable to make comparisons of a useful sort.

Accordingly in Table II. are shown the mean estimated annual populations of the Belfast Registration District in each quinquennium and decennium since 1871, calculated in various ways; (1) On the arithmetical means of the census populations, (2) on the assumption that the ratio of each intercensal increase has been uniform from census year to census year (geometrical mean), and (3) on the number of births registered in each period.

TABLE II.—Showing the approximate MEAN POPULATION of BELFAST REGISTRATION DISTRICT in certain periods of five years and ten years, as estimated in various ways.

Years.	(1) As estimated by Registrar-General for Ireland (arithmetical mean).	(2) As estimated by the British method (geometrical mean)	(3) As estimated by the number of Registered Births
Quinquennia—			
1871–1875	212,000	210,000	207,300
1876–1880	230,000	229,000	222,400
1881–1885	252,000	250,000	237,200
1886–1890	277,000	275,000	258,500
1891–1895	309,000	306,000	310,000
1896–1900	349,000	345,000	369,000
1901–1905	388,000	389,000	383,000
Decennia—			
1871–1880	221,000	220,000	215,000
1881–1890	265,000	263,000	247,800
1891–1900	329,000	326,000	339,000

We are of opinion that the figures of column 3 in this table more nearly approach the truth than those of the other columns. In this connection it is to be noted that while these figures confirm the indication of Table I. that the population of Belfast was under estimated in the nineties, they demonstrate also that the population was probably over estimated in the eighties, and in the seventies.

To complete this section of our Report, brief reference may be made to the various registration sub-districts—14 in number—into which the city is divided. Each of these districts is in the charge of a Medical Officer for the purpose both of registration of births, deaths and marriages, and of Poor Law Medical Relief, while he is also, *ipso facto*, one of the Medical Officers of Health of the city, a matter which will be dealt with in a subsequent part of our Report. But as to the population of these districts little is exactly known. There have been so many changes in their boundaries that the Registrar-General has abandoned the attempt to estimate their populations at present.

It may also be well to refer briefly to what is known as the sex and age constitution of the population of Belfast, since this is a matter which is of importance in comparing the rate of mortality from all causes and from individual diseases with that of other places, for it is obvious that comparisons must be fallacious if the constitutions of the populations compared are dissimilar. Thus, to take an extreme illustration, what may be a normal rate of mortality in a community of aged persons would be a very excessive rate in, for example, a school of young people.

In order to overcome this difficulty, statisticians adopt the plan of taking a standard population, and calculating factors of correction for populations deviating from it in respect of age and sex constitution. The standard population usually taken is that of England and Wales, and the Registrar-General for Ireland has ascertained that, compared with this standard, the correction factor for Belfast is 1·10033 ; that is to say, the population of Belfast was so constituted at the census of 1901, in respect of age and sex, that if the numbers dying in Belfast had been at the same rate in that year as actually prevailed in England and Wales, the death rate of Belfast would have required to be multiplied by the factor before it could equalise the death-rate of England and Wales. In other words, as was pointed out in evidence, the constitution, in regard to age and sex, of the Belfast population in 1901, favoured a lower rate of mortality than did the standard population of England and Wales.

Examination of the census population of the individual registration sub-districts shows that as regards their distribution of age and sex they differed widely from one another, and from Belfast as a whole.

Section III.

VITAL STATISTICS.

(*A.*)—SOURCES OF INFORMATION.

Detailed information regarding the vital statistics of Belfast is very difficult to obtain, in consequence of the fact that the Belfast Corporation is, as it always has been, unprovided with the necessary data. In this respect, the Belfast Corporation appears to be in the same position as all local sanitary authorities in Ireland, for the system by which such authorities in Great Britain are supplied with details of all deaths registered in the districts under their care does not prevail in that country. The reason for this difference appears to be that the provision of the Births and Deaths Registration Act, 1874, section 28, which requires local registrars to transmit copies of entries in their registers of deaths to the local authorities concerned, has no counterpart in the Registration Acts which apply to Ireland. The section in question of the English Act is so important that it is here quoted in full:—

> "Every Registrar, when and as required by a sanitary authority, as defined by the Public Health Act, 1872, shall transmit by post or otherwise a return, certified under the hand of such Registrar to be a true return, of such of the particulars registered by him concerning any death as may be specified in the requisition of the sanitary authority.
>
> "The sanitary authority may supply a form of the prescribed character, for the purpose of the return, and in that case the return shall be made in the form so supplied.
>
> "The Registrar making such return shall be entitled to a fee of twopence, and to a further fee of twopence for every death entered in such return, which fee shall be paid by the authority requiring the return"

The absence of this provision in Ireland has had the effect that no local authority appears to have the power of obtaining information which is of fundamental importance to them in their primary duty of searching for and coping with causes of ill-health and death among the population committed to their charge; and this, notwithstanding that in Ireland nearly every Registrar of Deaths is also a Medical Officer of Health. Theoretically, of course, there should, in view of this combination of offices, be no difficulty in the local authority getting acquainted through each of their Medical Officers of Health with the needful information. But, as a matter of fact, the reverse is the case, at any rate in Belfast. For it would seem that the Medical Officers of Health—of whom there are no fewer than fourteen in the case of Belfast—regard their duties as registrars as precluding them from imparting any of the information contained in the registers except in the manner provided by the regulations laid down by the Registrar-General. These regulations require a registrar to send to the Registrar-General for Ireland a weekly return of the number of births and deaths registered in his district, and a copy every quarter of all entries in the death registers, to allow "searches" in his registers under certain conditions, and so forth; but they do not require him to send any return to the local authority.

This attitude of the district registrars, while it may be technically correct, results in the remarkable anomaly that, although as Medical Officers of Health, they are required to keep the local authority informed as to all influences affecting injuriously the health of their districts, yet as registrars they do not give to the authority any of that information, bearing on those influences, which happens to be the most trustworthy in their possession.

This anomalous state of affairs is still further complicated in the case of Belfast, as also apparently in other towns in Ireland, by the fact that over and above the district Medical Officers of Health there is a Medical Superintendent Officer of Health, who has no connection at all with the registration

of deaths, and who therefore has no means of acquiring knowledge of any details of the deaths occurring either in his district as a whole, or in any of its sub-divisions.

The outcome of this state of affairs is that the only information at the disposal of the Belfast Corporation and their chief medical adviser, regarding current deaths in their city, is that contained in the "weekly summaries" of the Registrar-General. These summaries merely record the total *number* of births and deaths registered during a given week in the city as a whole, and in each of the sub-districts, together with the *number* of those deaths which were of infants under one year of age, of children under five, of persons aged between five and sixty years, and of persons sixty years and upwards; and the *number* of deaths *at all ages* caused by violence, the principal epidemic diseases, tuberculous diseases, diseases of the respiratory organs, pneumonia, and cancer, as well as the number of deaths which occurred in public institutions. The only other sources of information in this connection open to the Corporation are the quarterly returns of the Registrar-General, and his detailed annual reports. The annual report, however, is a volume which necessarily cannot appear until long after the year to which it relates has terminated; moreover, that and the quarterly returns, though they furnish information in more detail than the weekly summaries, deal only with registration districts, which, until recent years, did not include the city of Belfast as a separate entity. Furthermore, the data as to mortality given in these annual reports and quarterly returns are not corrected by distributing the deaths occurring in institutions among the sub-districts to which they properly belong.

Hence the absence of full information from the hands of the local registrar is not met by the information given in the official reports of the Registrar-General. Indeed, it is difficult to see how it could be met in this way. The official reports alluded to are on similar lines to those issued by the Registrars-General for England and Wales, and for Scotland, and to include in them information in sufficient detail to compensate for the absence of local information would be a stupendous task, even if it were possible.

The inadequacy of the present system can perhaps be best realised by pointing out that in Belfast, and presumably also in other localities in Ireland, the local authority and their chief medical adviser are in complete ignorance of the causes of infantile mortality. The cause of not one infant's death in the city is known to the Belfast Corporation.

Similarly the causes of death among children are quite unknown, or indeed the causes of death among persons of whatever age. Consequently it is impossible for them to know how various diseases are affecting their population in respect of age, or even in respect of sex, though this knowledge is often of the greatest possible importance in devising measures to cope with disease.

Likewise the Corporation are completely in the dark as to the places where deaths in the city are occurring, even from such important diseases as phthisis, tuberculosis, pneumonia, cancer, diarrhœa, or from diseases which may be due to industrial causes, to poverty, or to any of the other conditions which may be thought of as associated with modern town influences. And even in regard to the principal epidemic diseases, similar ignorance prevails except in regard to those which are notifiable under the Infectious Disease (Notification) Act.

It follows from this that the Corporation are in ignorance of the mortality occurring in particular sections of the city. It may well be that in some group of houses, for instance, or in some localised area, undue mortality from all causes or from certain groups of disease is taking place, or conversely, that an area is exceptionally favoured in this respect; but of either event the Corporation and their advisers have no means of judging.

It is therefore impossible for Belfast to institute what may be termed a "pathological register," in which to record the sex, age, residence, and

nationality of every deceased person, the size, situation, sanitary circumstances of his house, and so on, such as has proved of great value to other local authorities.

It is perhaps scarcely necessary to add that there is also complete ignorance as to the occupations which were engaged in by those who have succumbed to disease, a matter which, in an industrial city like Belfast, is worthy of close study.

Lastly, the construction of a "Life Table" for Belfast would appear to be quite impossible. Life tables are of great practical importance in many ways, and they have been prepared for London and others of the large cities in England and Scotland.

Dr. Whittaker, the former Medical Superintendent Officer of Health of Belfast, drew attention repeatedly in his annual reports to the foregoing fundamental defect in his sources of information, and recently the Corporation have endeavoured to repair it. They requested the Registrar-General to supply them weekly with, at least, details of the deaths registered as due to the principal epidemic diseases, and to phthisis, as he does in the case of Dublin, but we understand that the Registrar-General hesitates to adopt this course in consequence of the extra work which it would cast upon the local registrars, whose remuneration he is powerless to increase. Later on, in fact during our sittings, the Corporation sought to obtain this information from the local registrars themselves, and to pay them for it, but the Local Government Board, on inquiry being made whether such a plan would be sanctioned, were obliged to intimate that the Corporation had no legal authority to spend money in this way.

It is obvious that the matter cannot be allowed to rest thus. It seems unnecessary to recall the famous dictum of the late Dr. Farr, that vital statistics form the basis of all health reform—the truth of it is so plain; nor does it seem necessary to add that without the help of trustworthy vital statistics any health reforms attempted must be of the nature of leaps in the dark.

We feel, however, that we can hardly express ourselves too strongly on the importance of this question to Belfast, and apparently not to Belfast alone but to all Ireland. The most effective and most natural method of dealing with it is to follow the precedent of the English and Scottish Registration Acts, even if such a method involves fresh legislation, and we strongly recommend that this should be done and without loss of time. In view of the importance of the information as to the details of deaths occurring within the city we regret that the Corporation did not fall in with the suggestion made to them in October, 1907, by the Local Government Board for Ireland, which pending legislation would have enabled them to get the information desired. The proposal to obtain from the Registrar-General returns of the deaths ascribed to epidemic diseases and phthisis only, we consider to be quite inadequate to the necessities of the case.

(*B.*)—DEATH-RATE, PAST AND PRESENT, OF BELFAST, COMPARED WITH THAT OF OTHER LARGE CITIES.

We now proceed to discuss the general history, past and present, of Belfast mortality, and to compare it with that of other cities in Ireland and in Great Britain.

For this purpose reference involving much labour has been made to the successive Annual Reports of the Registrar-General for Ireland. For reasons already explained it is desirable in this matter to deal with the Belfast Registration District as a whole. The following table, based on data derived from these official sources, shows the average annual number of deaths from all causes registered in the registration district during successive quinquennia and decennia since 1871, together with the mean annual death-rates per 1,000 calculated according to various methods of estimating the population.

TABLE III.—Showing the average annual number of deaths from all causes registered during successive quinquennia and decennia in the Belfast Registration District, together with the mean annual death-rates per 1,000 living based on the various estimates of population, as set out in Table II.

—	Average annual number of Deaths	Mean annual death-rate per 1,000 calculated on Population estimated by—		
		1. Arithmetical Mean.	2. Geometrical Mean.	3. Number of Births Registered.
Quinquennia—				
1871–1875 ..	5,207	24·6	24·8	25·1
1876–1880 ..	5,450	23·7	23·8	24·5
1881–1885 ..	5,931	23·5	23·7	25·0
1886–1890 ..	6,487	23·4	23·6	25·1
1891–1895 ..	7,437	24·1	24·3	24·0
1896–1900 ..	7,988	22·9	23·2	21·6
1901–1905 ..	7,778	20·0	20·0	20·3
Decennia—				
1871–1880 ..	5,328	24·1	24·2	24·8
1881–1890 ..	6,209	23·5	23·6	25·0
1891–1900 ..	7,712	23·4	23·7	22·8

We have previously stated that there are reasons for believing that the estimates of population based on the number of births is more in accordance with actual facts than estimates framed in other ways, and therefore it is probable that the death-rates given in the third column of this table more nearly approximate the truth than those given in the other columns. It would thus appear that during the last twenty years there has been a marked and progressive fall in the death-rate in the Registration District from 25·1 in the period 1886-1890 to 20·3 in 1901–5. The figures in the first two columns show a rise in the death-rates in the quinquennium following 1890, but we have already shown that the official estimates of population in the decennium 1891–1900 must have been too low.

For purposes of comparison, the following figures have been obtained from data given in the decennial supplements of the Registrar-General. They show how Belfast stands in relation to the other two largest communities in Ireland, viz., Dublin and Cork :—

—	Mean Annual Death-rate per 1,000 living in the Registration Districts of—			
	Belfast.	Dublin North.	Dublin South.	Cork.
1871–1880 ..	24·1 (24·8)	27·9	27·4	23·5
1881–1890 ..	23·5 (25·0)	27·6	27·5	22·4
1891–1900 ..	23·4 (22·8)	25·9	26·3	21·6

The figures in brackets indicate the Belfast death-rates, based on populations estimated by the births. The other figures are all based on the arithmetical means of the populations at census years. It is to be noted that such estimates are much less liable to inaccuracy in the case of Dublin and Cork than in the case of Belfast, in view of the less rapid increase of population in those two Registration Districts.

It will be useful now to compare these records of Irish cities with those of other cities. For this purpose reference has been made to the decennial supplements of the English Registrar-General, and the records of six of the most populous cities have been examined. Since all these cities are comprised within several registration areas, it has been necessary to extract the records

of all these areas, work which has involved great labour and much calculation. Similar records for the City of Glasgow (not registration area) have also been obtained. The result is shown in the following table :—

TABLE IV.—Showing the mean annual average death-rate per 1,000 living from all causes during the decennia 1881-1890 and 1891-1900 in the *registration areas or districts* comprising the following cities :—

—	1881–1890	1891–1900
Belfast, ...	**23·5 (25·0)**	**23·4 (22·8)**
Dublin, North, ...	27·6	25·9
Dublin South, ...	27·5	26·3
Cork, ...	22·4	21·6
Liverpool, ...	25·2	23·2
Manchester, ...	24·1	22·5
Leeds, ...	21·7	20·1
Sheffield, ...	21·7	20·4
Bristol, ...	18·1	17·1
Birmingham, ...	19·2	19·4
Glasgow (City), ...	24·5	22·1

The Belfast figures in brackets are the rates based on populations estimated from the number of births registered. The table shows that the death-rates have generally fallen appreciably during the second decennium, and that the Belfast rates approximate those of Liverpool and Manchester, while they are lower than those of Dublin and higher than those of Cork, Leeds, Sheffield, Birmingham and Bristol.

It may now be of advantage to refer to the available records of these cities themselves in contradistinction to their Registration Districts. For this purpose reference has to be made to the weekly and annual "summaries" issued by the Registrars-General for England and Wales, Scotland, and Ireland, but it must be borne in mind in this connection that these summaries are issued in both countries on the responsibility of the local registrars alone, and before the actual returns are reviewed by the respective Registrars-General. Nevertheless, when dealing with mortality from all causes and with groups of years, these data may be regarded as sufficiently accurate.

Table V. shows the mean average annual death-rates of Belfast, Dublin and Cork cities during the decennium 1891-1900, and the quinquennium 1901-1905, as obtained from the official records mentioned.

The rates in this table are based on the populations as estimated by the Registrar-General for Ireland from year to year and as published in the annual summaries, but in the case of Belfast the death-rates based on populations estimated from the number of births registered are, as before, given in brackets.

TABLE V.—Showing the mean annual death-rates per 1,000 living from all causes in the cities of Belfast, Dublin, and Cork, in the decennium 1891-1900, and quinquennium 1901 to 1905 :—

	Belfast.	Dublin.	Cork.
1891-1900	24·7 (23·2)	29·8	24·8
1901-1905	20·8 (20·2)	24·8	21·5

From these figures it is apparent that the rates for Belfast are lower in both periods than those of the other Irish cities, and that in all three there has been a decided improvement during the last quinquennium.

Passing now to the other cities, the following table shows Belfast in comparison with the cities referred to in a previous table, and with London. It is to be noted that in this table the Belfast rates are based upon populations estimated by the same method as that adopted by the English Registrar-General in order to make them comparable. The figures in brackets are again rates based on populations estimated from the number of births.

TABLE VI.—Showing the mean annual death-rates per 1,000 living from all causes in Belfast and certain other *cities* in the decennium 1891-1900, and the quinquennium 1901-1905 :—

—	1891–1900.	1901–1905.
Belfast, ...	**24·2 (23·2)**	**20·1 (20·2)**
Liverpool, ...	24·5	21·5
Manchester, ...	23·9	20·2
Leeds, ...	20·2	17·4
Sheffield, ...	20·8	18·0
Bristol, ...	18·3	15·6
Birmingham, ...	20·8	18·6
London, ...	19·6	16·5
Glasgow, ...	22·1	19·5

This table indicates that all the rates have appreciably fallen in recent years, and that the Belfast rates are better than those of Liverpool, about the same as those of Manchester, and not so good as those of the other cities.

So far, *crude* or recorded death-rates have only been dealt with, but, as already explained, in the absence of correction for the varying age and sex distributions of the populations concerned, these rates are not strictly comparable. It is therefore desirable to make this correction, and as it is possible to do so for the period 1901-1905, taking England and Wales as the standard, with the aid of correction factors as supplied to us by the Registrar-General for Ireland in the case of Belfast and Dublin, and as published by the Registrars-General in their official reports in the case of other towns, the following table has been prepared :—

TABLE VII.—Showing the recorded and the corrected mean annual death-rates per 1,000 from all causes during 1901-5 in the following cities :—

—	Recorded or crude death-rate.	Factor for correction for sex and age distribution.	Corrected death-rate.
Belfast, ...	**20·1**	1·1003	**22·1**
Dublin, ...	24·8	1·0965	27·2
Liverpool, ...	21·5	1·0702	23·0
Manchester, ...	20·2	1·1169	22·6
Leeds, ...	17·4	1·0908	19·0
Sheffield, ...	18·0	1·0778	19·4
Bristol, ...	15·6	1·0262	16·0
Birmingham, ...	18·6	1·0759	20·0
London, ...	16·5	1·0511	17·3
Glasgow, ...	19·5	1·1075	21·6

It will be observed from this table that the relative position of the cities is not altered by the correction, except that Belfast is made to become appreciably better than Manchester.

Having thus examined Belfast mortality for groups of years, which for several reasons is the most trustworthy method, we may perhaps conclude this section of our Report by setting out the death-rate of the city year by year since 1891 as calculated from returns in the "weekly summaries."

This is accordingly done in the following table. Three series of figures are given, the first series being based on the populations as officially estimated each year by the Registrar-General for Ireland, the second series on populations estimated by the method adopted by the Registrar-General for England and Wales, and the third series on populations estimated from the registered births. For reasons already explained we regard the third series of figures as probably the most correct.

TABLE VIII.—Showing the death-rate of Belfast for each year since 1891, based on populations as estimated (1) by the Registrar-General for Ireland, (2) by the method of the Registrar-General for England and Wales, (3) by the number of registered births ;—

	1891.	1892.	1893.	1894	1895.	1896.	1897	1898	1899	1900.	1901.	1902	1903.	1904	1905.	1906.
(1).	25·5	26·5	25·8	24·6	26·2	25·1	25·7	25·5	22·7	21·3	22·0	21·1	20·0	20·8	20·0	20·1
(2).	25·4	26·1	25·2	23·7	25·1	25·7	24·0	23·8	23·7	22·8	22·0	21·0	19·4	19·7	18·5	18·6
(3).	**25·5**	**27·0**	**24·2**	**23·3**	**24·0**	**21·7**	**22·2**	**22·1**	**22·0**	**21·4**	**22·0**	**21·0**	**19·1**	**20·0**	**19·0**	**19·4**

The effect of the under-estimation of the officially estimated populations in the later nineties, to which we have already alluded, is strikingly shown in the first series of figures in this table. Apart from this, the steady fall of the death-rate in the period as a whole is the most prominent feature of the table, and this applies to all three series of figures.

We may, lastly, compare the annual record of Belfast since 1901 with that of other cities. For this purpose it is necessary to take the first series of figures in Table VIII. for comparison with Irish cities, and the second series for comparison with English and Scottish cities.

TABLE IX.—Showing the death-rates of the cities of Belfast, Dublin, and Cork for each year from 1901-1906, based on populations as estimated by the Registrar-General for Ireland :—

—	1901.	1902.	1903.	1904.	1905.	1906.
Belfast, ...	**22·0**	**21·1**	**20·0**	**20·8**	**20·0**	**20·1**
Dublin, ...	26·0	26·2	24·4	24·9	22 3	24·1
Cork, ...	23·0	21·5	19·4	21·6	21·7	20·0

TABLE X.—Showing for each year from 1901-1906 the death-rates of Belfast and of certain cities in England and Scotland, based on populations as estimated by the method of the Registrar-General for England and Wales :—

—	1901.	1902.	1903.	1904.	1905	1906.
Belfast, ...	**22·0**	**21·0**	**19·4**	**19·7**	**18·5**	**18·6**
Liverpool, ...	22·3	22·5	20·5	22·6	19·6	20·6
Manchester, ...	22·1	20·0	19·7	21·3	18·0	19·2
Leeds, ...	19·3	17·6	16·6	18·0	15·2	15·6
Sheffield, ...	20·4	17·1	18·6	16·8	17·0	16·4
Bristol, ...	16 0	17·4	14 3	15·6	14·6	14·5
Birmingham, ...	20·5	18 6	17·8	19 9	16·2	16·8
Glasgow, ...	21·2	20·0	19·2	19·3	17·9	17·8

It is apparent from this table that the Belfast record is about the same as that of Manchester, better than that of Liverpool, and not so good as those of the other cities.

This, in fact, seems to be the verdict of all the data which we have examined in connection with this matter. It seems clear therefore that, although the death-rate of Belfast, from all causes and at all ages, is by no means low, it cannot be maintained that it is, or that it has been in recent years, excessive,

as has been alleged, when compared with those of other large cities of the United Kingdom. Nevertheless, as we now proceed to show, mortality in Belfast, from certain diseases, and at certain ages, has been very high.

(*C.*)—CAUSES OF DEATH.

We requested the Registrar-General for Ireland to supply us with detailed statistical tables based upon the mortality returns of the city in the three years 1900, 1901 and 1902. A period of three years was chosen because deductions from the statistics of a single year are open to objection; while the particular period was chosen in consequence of the controversy, already alluded to, regarding the population of Belfast in recent years, which made it clear that the safest period to select was one which comprised a census year and the years immediately preceding and succeeding it.

The expense of procuring these tables was considerable, but we were of opinion that we had no option but to incur it, when it became apparent that, for reasons already set forth, the Corporation had no information of the sort required.

It is possible for the first time, with the aid of these tables, to examine in detail the causes of death in Belfast during the three years in question.

It is necessary to explain, however, that these tables have been prepared from mortality returns which have not been corrected for deaths in public institutions, that is to say, from returns which include the deaths of persons who did not reside in Belfast, but who went for treatment into institutions in the city and died there. The Registrar-General found it impossible to make correction for these deaths in these returns. To what extent the total number of deaths is increased by such deaths of non-residents it is not possible to say, but it is, no doubt, appreciable. On the other hand, no correction has likewise been possible for the deaths of Belfast residents who may have died elsewhere, and doubtless the balance is thus somewhat redressed, though not wholly so.

The Registrar-General has also supplied us with the "tabulating sheets," on which the Belfast deaths in the three years in question were tabulated in his office according to cause, age, and sex, for the purpose of preparing the above special tables. From these data, so tabulated, we have been able to obtain much valuable information.

Besides the Belfast tables, the Registrar-General supplied us with similar tables for the city of Dublin and the Dublin Registration Area. These, however, deal only with two years, 1901 and 1902, and, like those of Belfast, are uncorrected for deaths in institutions.

For purposes of further comparison we have, by our own investigation, obtained analogous figures for England and Wales, and for the city of Manchester. This city has been selected as a convenient one for comparison with Belfast, not only because, as already shown, its death-rate is, and has been for several years, similar to that of Belfast, but also because Manchester and Belfast are both industrial cities.

The figures for England and Wales have been obtained from the Annual Reports of the Registrar-General by averaging the published rates of the three years, 1900, 1901, and 1902 in each case. The rates for Manchester have been derived from data given in the Annual Reports of Dr. Niven, the Medical Officer of Health of that city, and are based on the average number of deaths in the three years in question and the Census population of 1901.

These latter figures are, therefore, strictly comparable with those of Belfast since they have been prepared in similar fashion, subject, however, to the reservation that the Manchester figures are corrected for deaths in institutions, and therefore somewhat favour Manchester in the comparison.

TABLE XI.—Showing for the cities of Belfast, Dublin, and Manchester, and for England and Wales, the mean annual death-rate per 1,000 of the population, represented by deaths, from all causes and from the under-mentioned causes and groups of causes, registered during the three years 1900, 1901, and 1902.

—	Belfast	Dublin *	Manchester.	England and Wales.
All Causes—				
Crude death-rate, ...	22·1	26·8	21·9	17·3
Death-rate corrected for age and sex.	24·3	29·4	24·5	17·3
A.—*General Diseases*—				
Small-Pox, ...	0·00	—	—	0·03
Measles, ...	0·64	0·60	0·49	0·35
Scarlet Fever, ...	0·04	0·17	0·23	0·13
Whooping Cough, ...	0·49	0·41	0·51	0·32
Diphtheria, ...	0·22	0·21	0·22	0·27
Fever—				
Typhus, ...	0·01	0·02	0·01	0·00
Enteric, ...	0·72	0·34	0·13	0·15
Pyrexia (origin uncertain)	0·06	0·02	0·00	0·00
Diarrhœa, ...	0·87	0·81	1·31	0·69
(*Foregoing Zymotic Diseases*),	(*3·05*)	(*2·58*)	(*2·90*)	(*1·95*)
Influenza, ...	0·17	0·36	0·26	0·30
Pneumonia (all forms), ..	1·54	1·68	2·57	1·31
Tubercular Diseases—				
Tubercular Phthisis and Phthisis.	3·17	3·05	2·10	1·28
Tubercular Meningitis, ..	0·26	0·41	0·24	0·19
Tubercular Peritonitis and Tabes Mesenterica.	0·14	0·37	0·18	0·18
Other forms of Tuberculosis, Scrofula, &c.	0·44	0·73	0·34	0·18
(*All Tubercular Diseases*), ..	(*4·01*)	(*4·56*)	(*2·86*)	(*1·82*)
Alcoholism, Delirium Tremens, &c.	0·09	0·11	0·14	0·10
Cancer, Sarcoma—Malignant Disease.	0·58	0·84	0·78	0·84
Premature Birth, Congenital Defects, Teething, &c.	0·60	0·83	0·92	0·86
Other General Diseases, ..	0·48	0·80	0·63	0·57
B.—*Diseases of Special Organs*—				
1. Nervous System—				
Convulsions, ...	0·53	1·14	0·34	0·54
Other Diseases, ...	0·93	1·14	0·90	0·71
2. Circulatory System, ..	2·72	3·28	2·67	2·39
3. Respiratory System, ..	3·05	3·91	2·45	1·76
(*Respiratory Diseases, including Pneumonia*).	(*4·59*)	(*5·59*)	(*5·02*)	(*3·07*)
4. Digestive System—				
Cirrhosis of Liver,	0·05	0·19	0·18	0·13
Other Diseases, ..	1·19	1·22	0·81	0·85
5. Urinary System, ..	0·44	0·75	0·51	0·48
6. Other Diseases of Special Organs.	0·26	0·34	0·24	0·25
C.—*Violence*, ...	0·57	0·63	0·76	0·62
D.—*Causes ill-defined and not specified.*	1·81	2·47	2·00	1·61

* The Dublin figures refer to two years only, 1901 and 1902

Table XI. on p. 17 gives the result of the foregoing investigations, and we now proceed to discuss briefly its main indications.

General Diseases.

Zymotic Diseases.—The foregoing figures show that the death-rate from the common epidemic or infectious diseases—the zymotic death rate—was very nearly the same in Belfast and Manchester, and that it was appreciably higher in these two cities than in Dublin. Scrutiny of the rates of the different diseases reveals two striking features. One is the excessive death-rate from enteric fever in Belfast—nearly six times as great as that of Manchester, and more than twice as great as that of Dublin. The other is the comparatively favourable death-rate from diarrhœa in both Belfast and Dublin Enteric fever is dealt with in a subsequent part of the report, page 31, and in the Addendum, but it may be noted here that, exclusive of this disease and diarrhœa, the zymotic death-rate was almost exactly the same in Belfast (1·46), Manchester (1·46), and Dublin (1·43), and that this rate approximated that of England and Wales (1·11).

Septic Diseases.—This term may, perhaps, be used for another important class of general diseases. It includes a variety of diseases due to septic processes, and, according to the present classification adopted by the Registrars-General, it also includes all forms of pneumonia. Deaths from "pneumonia," indeed, contribute the vast majority of the deaths in this class. It will be observed that there is a considerable difference between Belfast and Dublin and Manchester in respect of pneumonia, a difference which may be, aud probably is, due to differences in nomenclature. This disease will be referred to again in connection with mortality from respiratory diseases.

Tubercular Diseases.—The difference between Belfast and Dublin, in respect of tubercular diseases, as compared with Manchester and England and Wales, is strikingly shown in the table. The subject of phthisis in Belfast, on which a considerable amount of evidence was tendered to us, is reviewed in another part of the report (page 31).

Malignant Diseases.—The death-rate from cancer and other malignant diseases was appreciably lower in Belfast than in Dublin, Manchester, or in England and Wales.

Developmental Diseases.—These diseases, which include premature birth, congenital defects, and what is commonly called "teething," likewise contributed appreciably less to the Belfast death-rate than they did in Dublin, Manchester, or England and Wales. This class has an important bearing on infantile mortality, a subject which is discussed later on (p. 21).

Other General Diseases.—The most important of the remaiuing general diseases are rheumatic fever and other rheumatic affections, rickets, anæmia, diabetes, and alcoholism. The death-rate from these remaining general diseases was also decidedly lower in Belfast than the corresponding death-rate in Dublin, Manchester, and also in England and Wales.

As regards "alcoholism," it has to be borne in mind that this cause of death is one of those the real extent of which is not readily apparent in mortality returns. So far, however, as may be judged in this way it would seem that Belfast compares favourably not only with Dublin and Manchester, but also with England and Wales, for not only is the death-rate from 'alcoholism" itself less in Belfast than in the other places, but death-rates from such diseases as cirrhosis of the liver, and diseases of the urinary system, which may reasonably be regarded as indices to some extent of the effects of alcoholism, are also distinctly lower in the case of Belfast.

Diseases of Special Organs.

1. *The Nervous System.*—The diseases in this class include convulsions, inflammation of the brain and its coverings (meningitis), the various forms of insanity, and epilepsy. In Belfast they contributed somewhat more to the total death-rate than they did in either Manchester or England and Wales, but less than they did in Dublin. Examination of the "tabulating sheets" from which the special figures supplied to us by the Registrar-General of Ireland have been prepared, has shown that the excess of mortality from nervous diseases in Belfast as compared with England and Wales, was due almost entirely to excess of mortality from diseases classed as meningitis. Thus, in Belfast the death-rate from these affections amounted to ·42 per 1,000, as compared with ·22 in England and Wales, and ·29 in Manchester. In view of the prevalence of "cerebro-spinal-meningitis" in Belfast, this excess of "meningitis" in 1900–1902 seems to be of interest, and might with advantage be further examined.

2. *The Circulatory System.*—The principal diseases included in this group are various forms of heart disease, cerebral hæmorrhage, and "apoplexy." The "tabulating sheets" show that heart diseases, especially those of a more or less unspecified nature, accounted for more deaths in Belfast (2·07 per 1,000) than they did in England and Wales (1·51) or Manchester (1·84); but, on the other hand, apoplexy accounted for fewer deaths in Belfast (·57) than in either England and Wales (·75) or Manchester (·71). There is, however, no doubt room for differences of nomenclature in respect of these causes of death, and it will be noted that the death-rate from diseases of the circulatory system, as a whole, is broadly similar in Belfast and the other places given in the table, having regard to their respective death-rates from all causes.

3. *The Respiratory System.*—The excess of deaths from respiratory diseases in the three cities given in the table (2·5 to 3·9) as compared with England and Wales as a whole (1·8) is striking and important. There can be little doubt that such excess is partly due to town influences, and it is therefore of concern to health authorities.

The principal cause of death among the diseases in this class is bronchitis, the death-rate from which in Belfast was 2·58 per 1,000, as compared with 2·15 in Manchester and 1·46 in England and Wales.

Pneumonia is not included in this class, it being now regarded as a disease due to infective process. It is obvious, however, that between this disease and bronchitis there is considerable room for differences of nomenclature, and that an indication of the liability of any given community to chest diseases would be incomplete if pneumonia were left out of account. Thus it is difficult to see why, as Table XI. shows, Manchester should have suffered from pneumonia more than Belfast, and less than Belfast from bronchitis and other "respiratory diseases." The probable explanation is that in Manchester more deaths among fatal chest diseases were ascribed to pneumonia than to bronchitis than was the case in Belfast. Taking respiratory diseases and pneumonia together Belfast seems to have suffered less than Manchester, while both of these cities suffered less than Dublin, and all three much more than England and Wales.

4. *The Digestive System.*—The death rate from diseases of the digestive organs was appreciably higher in Belfast (1·24) than in either England and Wales (·98) or in Manchester (·99). This is a large group of diseases, many of which are of interest in a hygienic sense, including, as it does, such diseases as gastric ulcer, gastric catarrh, and other gastric diseases—affections not infrequently associated with disorders of the blood itself, due in turn, it may be, to unhealthy surroundings, to unhealthy conditions of work, improper food, alcoholism, and so forth—enteritis, gastro-enteritis, and other intestinal diseases, many of which have doubtless a close kinship with those forms of diarrhœa which constitute such an important element of the group known as zymotic; and cirrhosis and other diseases of the liver. We have already referred to the last-mentioned in connection with alcoholism.

As regards the various forms of gastric trouble, examination of the detailed figures supplied by the Registrar-General shows that in Belfast the death-rate from these diseases was ·28, while in England and Wales it was ·21, and in

Manchester ·23. In the case of enteritis and gastro-enteritis, however, there was a marked disparity in the figures, for in Belfast the death-rate from these affections was ·48, as compared with ·33 in England and Wales, and only ·17 in Manchester. It is almost certain that here again differences of nomenclature explain these diversities. There is admittedly very great difficulty in so defining "diarrhœa" on the one hand and "enteritis" on the other, as to ensure that deaths due to zymotic or epidemic causes shall be included in the former and excluded from the latter. We have already shown that in regard to diarrhœa, Belfast (·87) was in a more favourable position than Manchester (1·31), so that the above mentioned difficulty seems to be the most probable explanation of the contrary state of affairs in regard to "enteritis." To arrive at the best approximation to the truth as to liability to "diarrhœal diseases" for purposes of comparison, "diarrhœa" and "enteritis" may be classed together. If this is done with the data in our possession it will be found that Belfast had a death-rate from all diarrhœal diseases (including enteritis and gastro-enteritis) of 1·35 per 1,000, Manchester 1·48, and England and Wales 1·02. Manchester and Belfast were therefore somewhat similar in this respect.

5. *Urinary System.*—The most important diseases included in this class are the various forms of Bright's disease or inflammatory conditions of the kidneys; and they are of interest as indications to some extent of the effects of alcoholism, and also, doubtless, of unhealthy surroundings and conditions of work. It will be observed that the Belfast record in regard to these diseases is more favourable than any of the others. Here again, however, it is to be noted that differences of nomenclature may account for some at least of the discrepancies among the rates.

6. *Causes Ill-defined or not Specified.*—This group, which contributes a considerable share to the total death-rate, includes as its most important element deaths ascribed to two ill-defined causes in particular, viz.:—"atrophy or debility," and "old age." The latter cause accounted in England and Wales for a death-rate as high as ·9 per 1.000, as compared with only ·45 in Belfast and ·40 in Manchester. "Atrophy and debility," on the other hand, accounted for a death-rate in Belfast of 1·30 per 1,000, as compared with 1·12 in Manchester, and only ·60 in England and Wales. Again, the remainder of deaths in this group accounted for a death rate in Manchester of ·48 per 1,000, as compared with ·11 in England and Wales, and only ·06 in Belfast. There can be no reasonable doubt, however, that a great part of these variations must be due to differences of nomenclature.

It thus appears from examination of these records, and particularly from comparison of those of Belfast and Manchester, that in Belfast, mortality during the three years 1900, 1901, and 1902, was excessive from two causes in particular, namely, from enteric fever and tubercular diseases.

To a less extent, mortality in Belfast was excessive also from measles and from nervous diseases.

On the other hand, mortality in Manchester was relatively excessive from respiratory diseases (including pneumonia), scarlet fever, malignant disease, premature birth, &c., and alcoholism (including cirrhosis of the liver).

The excess in Manchester from respiratory diseases did not balance, however, the excess in Belfast from phthisis. Grouping phthisis and respiratory diseases together, it appears that the death-rate in Belfast from what may be regarded as all chest diseases was 7·76, as compared with 7·12 in Manchester.

D.—DISTRIBUTION OF DEATHS AS REGARDS AGE AND SEX.

This is a very important phase of any inquiry into the vital statistics of a community, involving, as it does, the question to what extent undue mortality is taking place among the younger and potentially more valuable members of the community.

It has been pointed out that the Belfast Corporation, like other local public health authorities in Ireland, have no data whereby they can ascertain facts in regard to this important matter. But the special returns of mortality which have been supplied to us by the Registrar-General for Ireland have enabled us to do so in regard to the years 1900, 1901, and 1902; and these facts appear to be so important and instructive that it is desirable to allude to them generally.

INFANTILE MORTALITY.

In the first place, it may be convenient to refer to the mortality of infants.

The following table sets out the average annual rate of infantile mortality of Belfast for each of the decennia 1881-1890, and 1891–1900, and for the quinquennium 1901–1905. For purposes of comparison similar rates for Dublin and Cork are given, as well as those for the large cities with which Belfast has been already compared. All the figures have been obtained from the reports of the Registrars-General.

TABLE XII.—Sbowing the mean annual rates of Infantile Mortality per 1,000 births registered in the decennia 1881–1890 and 1891–1900, and the quinquennium 1901–1905, in Belfast and other cities.

—	1881–1890.	1891–1900.	1901–1905.
Belfast, ...	**151**	**161**	**146**
Dublin, ...	175	172	158
Cork, ...	120	134	126
Liverpool, ...	183	191	172
Manchester, ...	179	190	173
Leeds, ...	173	179	165
Sheffield, ...	171	185	172
Bristol, ...	141	147	127
Birmingham, ...	167	187	171
London, ...	152	160	140
Glasgow, ...	147	149	140

Tbis table shows that Belfast holds a not unfavourable place as regards the death-rate of infants in comparison with other great cities in the United Kingdom : indeed all the three Irish cities named in the table compare favourably in this respect with the English cities. This feature of Irish cities is, as is well known, a feature also of Ireland as a whole.

It is important to know the causes of death of infants in Belfast, and to ascertain in respect of what causes the above comparatively favourable record is mainly due. A considerable amount of evidence on this subject was submitted by Sir John Byers, Professor Lindsay, Dr. M'Caw, and others in Belfast who have made a study of it. But although they were able to indicate the general causes of infantile mortality in other cities, and to draw general conclusions therefrom, they could not inform us of the causes of deaths of infants in Belfast itself. As already pointed out, these causes of death in Belfast are altogether unknown.

The actual causes of death of infants can only be ascertained in connection with the years 1900, 1901, and 1902 by means of the tables specially supplied to us. Table XIII. shows in detail the rates of infantile mortality from all the principal causes of death in Belfast during the three years in question, and for purposes of comparison similar rates for Manchester during the same three years, and for England and Wales during the decennium 1891–1900. The latter figures have been obtained from the decennial supplement of the Registrar-General for England and Wales, while the former have been obtained from data given in the Annual Reports of the Medical Officer of Health of Manchester.

TABLE XIII.—Showing, for Belfast and Manchester during 1900–1902, and for England and Wales in the decennium 1891–1900, rates of Infantile Mortality, per 1,000 registered births, from certain causes, from groups of causes, and from all causes, among infants under 1 year of age, and among infants under 3 months, between 3 and 6 months, and between 6 and 12 months of age.

—	BELFAST, 1900, 1901, 1902.					ENGLAND AND WALES, 1891–1900.					MANCHESTER, 1900, 1901, 1902.				
	Under three months.	Three to six months.	Six to twelve months	Total, under one year.		Under three months.	Three to six months.	Six to twelve months.	Total, under one year.		Under three months.	Three to six months.	Six to twelve months.	Total under one year
1. Common Infectious Diseases.	1·0	1·9	8·6	11·5		1·3	1·8	6·9	10·0		1·1	1·9	8·6	11·6
2. Diarrhœal Diseases, ..	6·4	8·6	11·3	26·3		7·6	9·1	10·3	27·0		7·6	11·8	15·0	34·4
3. Wasting Diseases, ..	35·0	3·1	2·2	40·3		33·6	3·9	2·5	40·0		39·6	6·7	3·8	50·1
4. Tubercular Diseases,	·5	1·3	2·8	4·6		1·4	2·5	4·0	7·9		1·5	2·8	3·9	8·2
5. Other Causes, ..	28·8	15·5	24·8	69·1		30·1	15·0	23·3	68·4		31·1	15·8	27·3	74·2
I.—Small-Pox, ..	–	–	–	–		–	–	–	–		–	–	–	–
Chicken Pox, ..	–	–	·1	·1		–	–	·1	·1		–	–	·1	·1
Measles, . .	·1	·5	3·8	4·4		·1	·2	2·8	3·1		·1	·3	3·4	3·8
Scarlet Fever, ..	–	–	·1	·1		–	·1	·2	·3		–	–	·2	·2
Diphtheria, ..	·1	·1	1·0	1·2		·1	·1	·5	·7		–	–	·4	·4
Whooping Cough, ..	·8	1·3	3·6	5·7		1·1	1·4	3·3	5·8		1·0	1·6	4·5	7·1
II.—Diarrhœa (all forms),	4·2	5·6	8·0	17·8		4·7	6·1	7·2	18·0		6·8	10·7	13·7	31·2
Enteritis, Gastro-enteritis, Gastritis, Intestinal Catarrh.	2·2	3·0	3·3	8·5		2·9	3·0	3·1	9·0		·8	1·1	1·3	3·2
III.—Premature Birth, ..	12·9	·1	–	13·0		18·7	·2	·1	19·0		19·8	·3	·1	20·2
Atrophy, Debility, Marasmus.	22·1	3·0	2·2	27·3		14·9	3·7	2·4	21·0		19·8	6·4	3·7	29·9
IV.—Tuberculous Meningitis,	–	·2	1·0	1·2		·2	·6	1·3	2·1		·3	·5	1·2	2·0
Tuberculous Peritonitis, Tabes Mesenterica.	·3	·4	·7	1·4		·8	1·3	1·6	3·7		·6	1·2	1·2	3·0
Other Tubercular Diseases.	·2	·7	1·1	2·0		·4	·6	1·1	2·1		·6	1·1	1·5	3·2
V.—Syphilis, ...	1·0	·3	·2	1·5		·9	·4	·2	1·5		1·1	·5	·3	1·9
Meningitis (not Tubercular).	·6	·9	2·1	3·6		·3	·7	1·5	2·5		·5	1·0	2·1	3·6
Convulsions, ..	6·9	2·9	2·8	12·6		11·2	3·9	3·1	18·2		5·5	1·6	1·8	8·9
Bronchitis, ..	6·1	5·0	7·5	18·6		5·0	4·3	7·3	16·6					
Laryngitis, ..	·2	–	·2	·4	29·7	–	–	·2	·2	26·4	8·1	7·9	16·8	32·8
Pneumonia, ..	1·8	2·7	6·2	10·7		1·8	2·3	5·5	9·6					
Suffocation (overlying).	2·2	1·0	·1	3·3		1·4	·5	·2	2·1		3·8	1·2	·4	5·4
Other causes, ..	10·0	2·7	5·7	18·4		9·5	2·9	5·3	17·7		12·1	3·6	5·9	21·6
All Causes, ..	71·7	30·4	49·7	151·8		74·0	32·3	47·0	153·3		80·9	39·0	58·6	178·5
	BELFAST.					ENGLAND AND WALES.					MANCHESTER.				

This table, which is well worth study by those specially interested in the subject, may be briefly summarised as follows :—

TABLE XIV.—Showing rates of Infantile Mortality per 1,000 registered births from certain groups of causes in Belfast and Manchester during 1900-1902, and in England and Wales in the decennium 1891-1900.

—	Belfast.	England and Wales	Manchester.
Common Infectious Diseases,	11·5	10·0	11·6
Diarrhœal Diseases, ...	26·3	27·0	34·4
"Wasting" Diseases, ...	40·3	40·0	50·1
Tubercular Diseases, ...	4·6	7·9	8·2
Respiratory Diseases, ...	29·7	26·4	32 8
Other Causes, ...	39·4	42·0	41·4
All Causes, ...	**152**	**153**	**179**

A striking feature of these tables is the low death-rate among infants in Belfast from tubercular diseases as compared with both England and Wales, and Manchester. Apart from this feature, the tables also show that Belfast's favourable record as compared with Manchester was due mainly to a smaller mortality from diarrbœal and from "wasting"* diseases, and also, though to a less extent, from respiratory diseases.

It thus seems that Belfast owed its lesser mortality of infants during the three years in question to both pre-natal and post-natal causes; tubercular, diarrhœal, and respiratory diseases belonging in the main to the latter, and "wasting diseases" in the main to the former category.

The relatively low rate of infantile mortality, which is a feature of Ireland as a whole as compared with England and Wales, has often been attributed to less artificial feeding of babies in the former country. The Belfast figures for 1900-2 are consistent with this explanation, particularly the strikingly low death-rates from tubercular and diarrhœal diseases. Divergencies in death-rates from diarrhœal diseases may be to some extent discounted by climatic differences, but the records as to tubercular diseases of infants can scarcely be explained in this way. They indicate that the "nursing" of infants by their mothers is more extensively and more thoroughly carried out in Belfast than in either England and Wales, or Manchester, an encouraging feature of Belfast's statistics which, we trust, will continue unabated.

The figures in Tables XIII. and XIV. indicate further, however, that pre-natal causes of ill-health and death among infants were also less operative in Belfast than in Manchester. From this it might be inferred that the conditions of female life there are not so inimical to maternity as they are in Manchester. Caution is needed, however, in accepting this deduction, for, as will appear later on, the death-rate of females at the child-bearing ages was considerably higher in Belfast than in Manchester during the three years in question, a fact obviously difficult of explanation if the above inference is correct.

Indeed, this discrepancy suggests, by way of explanation, that the registration of the deaths of infants may not be so complete in Belfast as in Manchester, and that an appreciable number of deaths of infants who have succumbed shortly after birth, as a result of prematurity, may not be recorded in Belfast This supposition gets confirmation from examination of Table XIII., from which it appears that Belfast's relatively low record as to "wasting" diseases was due almost entirely to a lower death-rate from "premature birth."

It seems probable, therefore, that the rate of infantile mortality in Belfast is somewhat understated. But making allowance for this defect, by assuming, for instance, that the death-rate from "premature birth" should be the same as that in Manchester, it seems plain that, nevertheless, infantile

* "Wasting diseases" is the designation given to such causes of death as premature birth, debility, congenital defects, &c.

mortality in Belfast is lower than in Manchester, and that, according to the data of three years, 1900-1902, this is due mainly to the effects of better nursing of infants.

While this is so far encouraging, it is not to be understood that the Belfast rate of infantile mortality is low, or as low as it might be. Steps should be taken to continue examination of the causes of death among infants, and as result to devise further means of reducing this mortality.

MORTALITY AT OTHER AGES.

The distribution of deaths at other ages than the first year of life may now be briefly considered. The following table has been prepared from the special returns supplied to us for Belfast, and from the Annual Reports of the Medical Officer of Health of Manchester, and they show for these two cities, in the years 1900, 1901, and 1902, the average annual death-rates from all causes at certain groups of ages per 1,000 of the population living at each of those groups at the Census of 1901.

TABLE XV.—Showing for Belfast and Manchester, in the years 1900, 1901, and 1902, the mean annual death-rates from All Causes at various age groups per 1,000 living at each of those groups at the Census of 1901, among persons of both sexes, and among males and females separately.

—	1–5.	5–10.	10–15.	15–20.	20–25.	25–35.	35–45.	45–55.	55–65.	65 upwards.	All ages.
Belfast.											
Males, ...	30·0	5·8	4·5	7·4	9·5	10·9	15·3	25·3	51·0	103·5	22·4
Females, ...	33·2	7·2	5·5	8·8	8·2	11·4	16·2	24·6	44·2	99·2	21·8
Both sexes, ...	31·9	6·5	5·0	8·1	8·7	11·2	15·8	24·9	47·1	100·9	22·1
Manchester.											
Males, ...	32·8	5·5	2·7	4·2	5·6	8·2	17·8	31·7	57·0	120·0	23·4
Females, ...	31·5	5·7	3·1	3·3	4·9	7·0	14·3	24·1	45·1	103·8	20·4
Both sexes, ...	32·1	5·6	3·0	3·7	5·2	7·6	16·0	27·7	50·5	110·3	21·9

The facts disclosed by this table are of great importance.

It will be observed that while the death-rate at all ages was, for these three years, practically the same in both cities, the death-rates at the younger age groups were much higher in Belfast than in Manchester, with the exception of the ages 1–5. At this age group the death-rate was about the same in both cities, but in the next age group, 5–10, the Belfast death-rate had commenced to exceed that of Manchester. This excess increased at the next age group, and culminated at the age group 15–20, where the Belfast death-rate was more than double that of Manchester. After this age the excess of Belfast over Manchester, though still great, was relatively less, and at 35–45 the death-rates were practically identical. In the later ages of life the Manchester rates somewhat exceeded those of Belfast.

The table thus shows that in Belfast there was a greater loss of life among children and young adults, especially between the ages 10–35, than there was in Manchester. This is obviously a fact of much importance to Belfast, and one that demands explanation It is to be borne in mind in this connection that, as already shown, the death-rate in Belfast in the first year of life was considerably *lower* than that in Manchester, and that in the first five years of life the mortality was about the same in both cities.

Assuming, therefore, that the figures for the three years in question are not unusual, the problem is to ascertain what influences are at work to produce this relatively heavy mortality among young people in Belfast, notwithstanding the fact that they appear to pass through their first five years of life with less chance of death than those residing in Manchester.

There are, however, further features of this problem which the table shows to be of a striking nature. Thus, the table shows that in Belfast the death-rate among females was *higher* than that among males at every age group under 45, with only one important exception, namely, at ages 20–25; whereas in Manchester the death-rate among females was *lower* than that among males throughout all the age groups, with insignificant exceptions at ages 5–15. Moreover, it also shows that the excess of the female death-rates in Belfast over those in Manchester began to be appreciable at the ages 5–10, and extended to the ages 35–45, while the excess of the male death-rates did not begin to be marked until the ages 10–15, and ceased with the ages 25–35.

Thus it would seem that influences exist in Belfast, if these three years may be accepted as an indication, of a sort to cause undue mortality among all young people, but especially so among females between the ages of 5 and 45, that is to say, among females during a period of life which embraces the school age, the age of puberty most of all, the young working age, and also the child-bearing age.

In order to obtain an insight into the important questions raised by the foregoing figures, it would be necessary not only to analyse according to age and sex all the main causes of death in Belfast during the three years for which special returns have been supplied, but also to analyse data of similar sort in regard to other years; in regard to other cities in Ireland; and in regard to Ireland as a whole.

Time does not permit of us entering upon such a task, important as it is, although, as will appear later, we have something to say in this connection in regard to the mortality in Belfast which is attributed to phthisis. It must suffice to point out here the all-important facts indicated by these mortality returns, and to commend their detailed analysis to the Belfast Corporation.

It is obvious that the facts disclosed by these special returns emphasise, if emphasis is needed, the essential importance of supplying the public health authority with detailed returns of all the deaths which occur in their district.

We now proceed to discuss two causes of death which are of particular importance in Belfast, namely, Enteric Fever and Phthisis.

(*E.*)--ENTERIC OR TYPHOID FEVER.

The available evidence and data relating to enteric or typhoid fever (including "simple continued fever") in Belfast have been collated by one of us, and his special study and conclusions, together with certain diagrams, are embodied in the addendum, which accompanies our Report.

Mortality from enteric fever in Belfast has been excessive in almost every year since the time (1872), when deaths from this disease were first separately recorded in the returns of the Registrar-General for Ireland.

For the last twenty-five years, at least, the mean annual mortality from this disease has been so great in Belfast that no other city or town of the United Kingdom equals or even approaches it in this respect.

This mortality in Belfast during the last completed decennium (1891-1900), as compared with that preceding it, was, in contrast with most other towns, actually greater by as much as 50 per cent.; the death-rate having increased from ·50 to ·75 per 1,000. This increase in Belfast was confined mainly to the latter half of the decennium, from the end of 1896 onwards, reaching its acme in 1898, when the death-rate was as high as about 2 per 1,000.

Since 1901, when the death-rate was also very high (about 1 per 1,000), the annual mortality from fever in Belfast has diminished considerably, but it has, nevertheless remained unduly great as compared with other large towns of the United Kingdom.

The influence of insanitary conditions, using this term in its widest sense, in maintaining this excess of fever in Belfast has no doubt been very great, but there are serious difficulties in the way of attributing the fever mainly to this influence.

One difficulty is the very excess of the fever, which has been so great as to make Belfast unique in this respect among communities in the United Kingdom. Had insanitary conditions been mainly responsible, these conditions should themselves have been unique. This is not the case. Bad as the circumstances of Belfast, in a sanitary sense, undoubtedly are in many ways, it cannot be contended that, in this respect, Belfast is on an altogether lower plane than other cities and towns of the United Kingdom.

Another difficulty is the increased abundance of the disease in the latter half of the decennium (1891-1900), which occurred in spite of important sanitary improvements, and co-incident improvement of the general health in Belfast, as indicated by a falling death-rate from all causes and from other diseases of the zymotic class.

A third difficulty is that, in the last five or six years, mortality from fever in Belfast has remained excessive, though less than formerly, notwithstanding a great sanitary reform by which nearly all the privies in the city have been abolished.

Moreover, it would appear that fever in Belfast has not been exceptionally prevalent in areas where grossly insanitary conditions were conspicuous.

In view of these facts, and making every allowance for the influence of insanitary conditions in fostering fever, such as is suggested by experience elsewhere, we are of opinion that they cannot alone suffice to explain the unparalleled amount of fever in Belfast, and that the evidence, as a whole, strongly points to the operation of some additional fever agency.

The magnitude of Belfast fever, especially in the years 1897–1901, undoubtedly suggests the public water-supply of Belfast as a not improbable cause. But on close examination of the facts, it appears that there are very great obstacles to so explaining it.

The issue involved is of great importance, an impression having widely prevailed in Belfast that the water supply has been mainly responsible for fever. Professor Lorrain Smith, in two reports presented by him to the Corporation, specifically impugned the water supply as having been "the primary cause of the excessive amount of fever in Belfast," especially that part of the supply which is derived from Stoneyford, on the gathering ground of which cases of enteric fever from time to time occurred.

In these reports Professor Lorrain Smith did not show that any relation existed between the distribution of the implicated water and the distribution of fever in Belfast, although such a demonstration must be considered essential to the maintenance of his proposition. Also, he was misled as to the date of introduction of the Stoneyford water into the city, which invalidated one of the principal arguments used by him in support of the indictment against this water, whereby he connected an appreciable rise in the death-rate from fever in Belfast, which commenced with the year 1889, with the introduction of Stoneyford water. He supposed that this took place at the end of 1888, whereas, as a matter of fact, the water was not introduced into the city until the beginning or middle of 1890, the year following the rise of fever noted by him.

A feature of Belfast fever which weakens suspicion against the water supply is, that there never has been an "explosion" of the disease on the scale which has been characteristic of epidemics of fever which have been disseminated by public water services infected at their sources. This absence of explosiveness is illustrated in the addendum by means of diagrams (Nos. 1 and 2)* which compare the behaviour of the disease in Belfast as a whole, and in some of its sub-divisions, with that exhibited during water epidemics which occurred at Maidstone, Worthing, and Lincoln.

These diagrams, and also diagrams Nos. 3 and 4, illustrate even more important difficulties in the way of connecting Belfast fever with the water supply. Like the "spot maps" (facing p. 116) and the table of "attack-rates" (Table V. in the addendum), they indicate the absence of definite relation between the distribution of fever and the distribution of the two distinct supplies of water (Stoneyford and Woodburn).

They also illustrate another essential feature of the Belfast fever problem, namely, that whatever agency has mainly been at work, it has been capable of operating more or less *simultaneously* and more or less *similarly* in diverse parts of the city, quite irrespective of what the areas of water supply are supposed to have been, and in spite of a diversity of local conditions.

Attempts to associate the facts relating to distribution of water in the city with the main facts of the distribution of fever fail to satisfy the last-mentioned essential condition. Thus the only way in which Stoneyford water can be held responsible for simultaneous behaviour of fever in diverse parts of the city, involves the assumption that this water passed, not occasionally, but habitually and in large quantities to all parts of the city, an assumption which must be regarded as altogether out of the question, in view of the fact that this water was strictly limited in amount, and was the only supply available for the higher levels of the city.

On the other hand the only way in which Woodburn water can be held responsible for the simultaneous exhibition of fever, is by the assumption that it passed habitually to the higher levels of the city where fever was abundant. This again is an assumption which cannot be entertained for the reason that it has been physically impossible to send Woodburn water to these higher levels since the introduction of Stoneyford water.

Moreover, it would appear that even if there had been only one water supply instead of two in Belfast up to 1901, it would be difficult to account for the fever by attributing it to such supply. Examination of the map facing p. 128, and the "spot maps" already referred to, as well as the evidence given before us indicate that, since 1897 at least, fever in Belfast has been mainly limited to the quarters of the city occupied by the working classes. The public water service cannot account for fever so limited.

We are of opinion, therefore, that it is not consistent with the facts to hold the Belfast water supply responsible for fever in Belfast since 1897.

Prior to 1897, there are no notification data in Belfast to assist us, but the Registrar-General's quarterly mortality returns do not indicate that the general behaviour of the disease materially differed then from its behaviour since 1897. They also show that the introduction of Stoneyford water produced no appreciable impression on fever mortality in the areas of the city to which it was newly supplied. If Woodburn water had until then been disseminating fever, mortality should have been greatly reduced in the areas to which Stoneyford water was newly supplied; and conversely, if Stoneyford water had been responsible, mortality should have greatly increased in these new Stoneyford areas. As a matter of fact, however, neither of these events happened.

(* See p. 114).

It is not probable, therefore, that before 1897, fever in Belfast was disseminated by the water supply of the city.

It is only when the problem is considered in relation with shellfish that the main features of Belfast fever appear explicable. Its excess, for at least thirty years; its limitation in the main to the working classes; its similar and simultaneous behaviour in widely separated parts of the city; its great increase in the latter half of 1891-1900; its diminution since 1901; and, lastly, its remaining in excess, even now in spite of important sanitary improvements, are all alike consistent with a thesis that shellfish—that is cockles and mussels, which are obtainable in abundance from the polluted foreshores of Belfast Lough in the immediate vicinity of the city, and are mostly eaten raw in Belfast—have played an important part in the production of that fever.

Moreover, the known subsidiary features of the history of this fever also appear to be not inconsistent with explanation in this way, notably the fall of the fever death-rate in the early eighties, when interference with the gathering of shellfish occurred because of some reclamation of foreshore; its rise in 1889, when some increase of foreshore pollution seems to have taken place; the grouping of the main fever areas in the city; the different incidence of fever on the two Stoneyford water areas; the incidence of fever on Ligoniel under two different water supplies; the immunity of persons resident in institutions; and the immunity enjoyed by Jews, with whom shellfish is prohibited as an article of food.

It is manifest also that what is known of the seasonal incidence of fever on Belfast is not inconsistent with the shellfish hypothesis. The diagrams clearly indicate that, for the most part and especially before 1902, there was marked tendency of Belfast fever to increase in the warmer months and to diminish in the colder months of the year. Although there is evidence that in the nineties Lough shellfish were hawked in the street throughout the year, it is but reasonable to suppose that larger quantities of this food were obtained and consumed in the warmer months than in the colder months.

Lastly, the circumstances of Belfast seem to be exceptionally favourable to the operation of shellfish as a fever producing agency, as extensive gathering grounds polluted by sewage are within easy reach of the large working-class population.

The position therefore is that the known features of the history of Belfast fever are consistent with an explanation attributing them to the influence of shellfish, while many of these main and minor features are not consistent with explanations attributing them to the influence of either insanitary conditions or water supply.

It does not, of course, follow that shellfish have been the universal or almost universal direct cause of attacks of fever in Belfast. The correct interpretation appears to be that shellfish have been the means of keeping the disease constantly alive, as it were, in Belfast, and that not only have they been the "additional fever agency" referred to when discussing the influence of insanitary conditions, but that this additional fever-agency has largely controlled the course of events, not necessarily as the direct cause of a greater number of cases of fever than all other agencies, but by repeatedly furnishing opportunities for these other agencies to come into operation.

The most important of these other agencies have no doubt been "insanitary conditions," using this term in its widest sense, and to include the effects of inefficient sanitary administration extending over many years. Indeed it may be surmised that with an agency like shellfish repeatedly in operation—daily, at times, as it must have been in Belfast—insanitary conditions have been provided with every opportunity to operate to the full in fostering the disease.

Practical Results of the Study of Enteric Fever in Belfast.

Importance of ascertaining and recording all the facts.

One lesson which may be derived from the study of enteric fever in Belfast is the need for the careful and systematic investigation of all cases of this disease and of all cases designated simple continued fever, and for the careful and systematic record of all the facts that may be learned from these investigations, such as can only be supplied by the guidance of a skilled Medical Officer of Health, well versed in all the considerations that require elucidation. As a corollary to this there is need also for detailed observation and study of the distribution of the disease and of its manner of incidence, without which not only can no deductions of value be made as to the cause or causes operating to produce it, but also without which there is risk of arriving at conclusions which cannot be brought into agreement with the actual facts.

Need for sanitary improvements in Belfast.

Another lesson is that the very fact that the incidence of fever in Belfast has been, and, indeed, still is so heavy, supplies a very cogent reason for taking all possible steps to improve the sanitary conditions and sanitary administration of the city. There can be no doubt that insanitary conditions have played a very important part in the dissemination of the disease. These conditions are dealt with in a later part of our Report, but those which seem to call for particular and immediate attention, from the fever point of view, are :—

(1) The complete abolition of privies ;

(2) The removal at short intervals of refuse matter from houses ;

(3) The daily destruction of all such refuse ; or, if the alternative be possible, its daily removal beyond the limits of the city, so as to avoid its accumulation in " depots " within the city ;

(4) The proper paving of all back yards and back passages of houses, and their frequent cleansing ;

(5) The careful supervision of house drains ;

(6) The careful supervision and systematic flushing of sewers ;

(7) The removal of causes of " flooding " ;

(8) The inculcation of cleanliness on the people themselves, and repeated and systematic house inspection by skilled officers ;

(9) The removal to hospital of as many cases as possible of both enteric fever and continued fever, and the efficient disposal of excreta ; and

(10) The investigation, bacteriologically, of cases notified as simple continued fever, as well as of doubtful cases of enteric fever.

The water supply.

In regard to the water supply, it cannot fail to be regretted, that suspicion was so exclusively cast upon the water supply, and this not only because of the unnecessary public anxiety it occasioned, but also because it caused other and probably more correct interpretation of the facts to be overlooked.

Need for co-operation between or amalgamation of Water Commissioners and Corporation.

This suspicion, however, could hardly have arisen to any important extent had there been that close co-operation between the Corporation and the Water Commissioners which would have secured a complete interchange of the facts and knowledge within the possession of each. Complaint was made by the Corporation, on the one hand, that they had no knowledge of the distribution of the water, while the Water Commissioners, on the other hand, were without precise knowledge of the distribution of fever. It may be said that it required the appointment of a special Health Commission in order to bring together the two sets of facts possessed by these two bodies. Obviously, such a state of things is wrong.

Need for safeguarding water supply.

On the other hand, the water supply of Belfast has greatly benefited from the suspicion which has attached to it. For this suspicion has led to the purchase of farms on the gathering grounds and the dispersal of that part of the population thereon, which, from its proximity to the reservoirs, constituted the greatest potential danger to the supplies. Moreover, it may fairly be hoped that since the water failed to develop fever distributing capacity from its sources prior to this improvement, and notwithstanding the existence of enteric fever on one of the gathering grounds, there is all the more reason now for confidence in the unlikelihood of such occurrence in the future. This

confidence, however, will only be justified provided that great and constant care is bestowed on the water in all stages of its preparation. It is to be hoped, therefore, that the appointment of a bacteriologist to assist in the constant supervision of the efficacy of these various stages, which was foreshadowed by the Water Commissioners during our sittings, will speedily take effect.

Sewage disposal and shellfish.

As regards shellfish, the most important practical question relates to sewage disposal. Although the Corporation should continue to endeavour to prevent the sale in Belfast of shellfish obtained from the Lough, and to dissuade persons from gathering such shellfish for their own consumption, by means of warning notices, it cannot be denied that they have no power to do anything more.

Importance of question extends beyond Belfast.

It has to be borne in mind, too, that the importance of this question extends far beyond the limits of Belfast, and this in no insignificant degree; for it appears from the official returns of imports and exports for Belfast that 382 tons of shellfish were exported in 1905, 461 tons in 1906, and 466 tons in 1907. The responsibility, therefore, of the local authorities in this matter is a very heavy one, even though it be assumed that only part of this export is intended for use as human food.

Obviously, therefore, something must be done, and the question arises whether it is practicable to purify the sewage pouring into the Lough so as to make it harmless in regard to shellfish.

Views of Royal Commission on Sewage Disposal

The Royal Commission on Sewage Disposal have specially considered this question of the discharge of sewage into tidal waters in connection with shellfish, and have fully dealt with the matter in their Fourth Report. The recommendations of this Report on this matter are so important and so applicable to the case of Belfast, that some of them may be quoted in full:—

"33. It has been suggested that the evils (*i.e.* contamination of shell-fish) would be removed if the law were altered so as to require that all sewage should be purified before its discharge into tidal waters. We do not consider that any such sweeping alteration of the law could be justified. There are undoubtedly many cases, where shell-fish are not concerned, in which the discharge of crude sewage into such waters does not, according to present knowledge, cause any harm, and to require purification in all cases would lead to the waste of large sums of money. And even where shell-fish have to be considered, such an alteration of the law would not always meet the necessities of the case.

"34. In our Interim Report dated the 12th July, 1901, we pointed out that the effluents from sewage farms as well as effluents from artificial purification processes usually contain large numbers of micro organisms, many of which appear to be of intestinal derivation. Since that time we have examined many more effluents of both classes, but have no reason to alter our opinion that such effluents must be regarded as potentially dangerous, inasmuch as they may still contain disease organisms. We would particularly refer to the experiments which Dr. Houston has made with *B. pyocyaneus* . . . . It will be seen that this micro-organism, which was added to the sewage in large numbers, passed freely through sewage purification works, consisting of—(*a*) septic tank and contact bed, (*b*) continuous filter about 10 feet in depth.

"With the advance of knowledge it is possible that some method of sewage treatment may be devised by which, within reasonable limits of cost, the dangerous qualities of sewage may be wholly eliminated, but the treatment of sewage, according to methods at present in use, cannot be relied upon so to alter its character as to allow of its discharge in the immediate neighbourhood of shell-fish layings, without incurring appreciable risk of disease being communicated by the consumption of shell-fish taken from such layings.

"In such cases either the sewage outfall must be removed or the layings closed. . . . .

"38. In our opinion no general enactment as to the treatment of sewage or as to the seizure of unwholesome food would meet the necessities of the case; the remedy must be found in connection with the waters, foreshores, ... and layings themselves.

Sewage Commission recommends control of shellfish beds as only real remedy.

"39. After carefully considering the whole of the evidence, together with the results of our own investigations and local inquiries, we are strongly of opinion that the only way in which this evil can be effectively dealt with is by placing tidal waters under the jurisdiction of some competent authority, and conferring on that authority *power to prevent the taking of shell-fish for human consumption from any position in which they are liable to risk of dangerous pollution.* . . ."

Treatment of sewage not likely to safeguard shellfish.

There seems to be little doubt that if sewage purification processes cannot be relied upon generally to completely safeguard shellfish, least of all is it likely that they will avail in the circumstances of Belfast Lough, with its shallow waters and sluggish currents, and with the vast volumes of sewage required to be dealt with.

Moreover, there is other sewage than that of Belfast to be thought of, which, though relatively small in quantity, is discharged in some cases directly upon the shellfish beds themselves, quite fresh, and without

restriction of any kind. Indeed, it may be surmised that some of these local sewage discharges may be even more dangerous as regards shellfish than that of Belfast.

The only effectual remedy, short of a vast foreshore reclamation scheme, is that indicated by the Royal Commission on the Disposal of Sewage, namely, to prohibit the gathering of such shellfish by anybody, unless it is clear that they are not to be used for human consumption.

Before this obvious and apparently simple remedial measure can be carried out, new powers will have to be conferred either on the Belfast Corporation, or on a "joint board" comprising the authorities of districts bordering the Lough, or on some other "competent authority"; but in view of the importance of this matter to the public health in Belfast, and possibly elsewhere, we are of opinion that these powers should be conferred with as little delay as may be.

We trust that the decline of fever mortality which has taken place in Belfast since 1901 will not inspire a false confidence in the future, and so result in inaction. It is to be borne in mind that this mortality, though diminished, is still unduly great as compared with other towns, and that there can be no certainty, under existing circumstances, in the maintenance even of this diminution.

The Belfast Corporation and other authorities concerned should, meanwhile, continue, by every means in their power, measures in prevention of the sale of Lough shellfish as human food, and should in all ways dissuade private gatherers from obtaining them for their own consumption.

It may also be matter for consideration whether the powers conferred by the Public Health (Regulations as to Food) Act, 1907, may be usefully applied to this question so far as it relates to "the prevention of danger arising to the public health from the . . . . distribution of" shellfish, "intended for sale for human consumption."

In view of the large export of shellfish from Belfast, the applicability of this Act for the purpose indicated appears to deserve consideration, not only by the Local Government Board for Ireland, but also by the corresponding central departments for England and Wales, and for Scotland.

(F.)—PHTHISIS.

It has been shown in Table XI. that in the three years 1900-1902 the mean annual death-rate per 1,000 from phthisis in Belfast (3·17) was excessive as compared with that in Manchester (2·10) and with that in England and Wales (1·28), and also that it exceeded the death-rate from like cause in Dublin (3·05).

The Registrar-General for Ireland in his Annual Report for 1905 drew special attention to the statistics of phthisis and tubercular disease generally in Ireland. He showed in this report that in England and Wales and in Scotland the death-rate from phthisis has more or less steadily diminished during the last forty years, while in Ireland it has remained stationary or has even increased, and also that for nearly twenty years past the death-rate in Ireland from this cause has been considerably higher than that in either England and Wales or Scotland, although previously it had been lower. He further showed that in Ireland the death-rate among females from phthisis is greater than that among males, whereas in other portions of the United Kingdom the reverse is the case; and also that there are striking differences in the incidence of phthisis mortality on different ages.

It thus appears that excessive mortality from phthisis in Belfast is not exceptional for an Irish city, and although we heard a considerable amount of evidence from Dr. King Kerr, Sir John Byers, Professor Lindsay, and others, on the subject, it is plain, that before attempting to explain satisfactorily the causes of such excess in Belfast, it would be necessary to ascertain the causes operating to produce similar excess in Ireland as a whole.

Such an investigation is obviously outside our province, and all that it seems possible for us to do is to set out the main facts regarding phthisis in Belfast, and to indicate the most important considerations which seem to be involved.

In the first instance, it may be desirable to briefly show the broad features of phthisis mortality in Belfast in comparison with other towns, and not only of mortality from this disease, but also that from respiratory diseases, so as to obtain some insight into the behaviour of chest diseases generally. The following table has been prepared for this purpose :—

TABLE XVI.—Showing the mean annual rate of mortality per 1,000 from Phthisis and from Respiratory Diseases during the decennia 1881–1890 and 1891–1900, in the Registration Districts in which are comprised Belfast and certain cities, and in the city of Glasgow (not Registration District):—

—	1881–1890			1891–1900		
	Phthisis	Respiratory Diseases	Total.	Phthisis.	Respiratory Diseases.	Total.
Belfast, ..	**3·72**	**5·16**	**8·88**	**3·41**	**5·11**	**8· 2**
Dublin, ..	3·53	5·59	9·12	3·38	5·12	8·50
Cork, ..	2·94	4·86	7·80	3·36	4·07	7·43
Liverpool,	2·35	5·64	7·99	1·85	5·28	7·13
Manchester,	2·31	5·57	7·88	2·03	4·94	6·97
Leeds, ..	1·81	4·57	6·38	1·54	4·16	5·70
Sheffield, ..	1·90	4·93	6·83	1·35	4·28	5·63
Bristol, ..	1·67	3·56	5·23	1·37	3·31	4·68
Birmingham	1·66	4·16	5·82	1·47	4·00	5·47
Glasgow City,	2·88	5·11	7·99	2·13	4·36	6·49

It thus appears that in both these decennia the mortality referred to phthisis was greater in Belfast and the other Irish cities than it was in the English and Scottish cities named, and that the mortality referred to phthisis and respiratory diseases together, that is chest diseases generally, was also greater in Dublin and Belfast than in these English and Scottish cities.

There is, however, indication that this mortality, from both phthisis and respiratory diseases, was less in the second decennium than in the first in the Irish cities (except Cork in the case of phthisis) as well as in the English and Scottish cities.

It may be useful to examine the record of Belfast in this respect in somewhat greater detail. In the following table is shown the average annual mortality referred to phthisis and respiratory diseases in the Belfast Registration District in successive quinquennia. The rates are based on the population figures given in Table II. (column 3).

TABLE XVII.—Showing for the Belfast Registration District the average annual number of deaths and mean annual death-rates per 1,000 referred to Phthisis and Respiratory diseases in successive quinquennia :—

—	Phthisis.		Respiratory Diseases		Total Death-rate.
	Deaths	Death-rate.	Deaths.	Death-rate	
1871–1875, ...	828	4·00	949	4·58	8·58
1876–1880, ...	860	3·87	1,257	5·65	9·52
1881–1885, ...	929	3·92	1,329	5·60	9·52
1886–1890, ...	1,039	4·02	1,399	5·40	9·42
1891–1895, ...	1,128	3·64	1,695	5·47	9·11
1896–1900, ...	1,117	3·03	1,670	4·53	7·56
1901–1905, ...	1,134	2·96	1,651	4·31	7·27

These figures show that the rate of mortality referred to phthisis, and also that referred to respiratory diseases, have been steadily, though slightly, diminishing in the Belfast Registration District since the quinquennium 1886-1890.

Much the same indication is derived from a study of the records of Belfast city as distinguished from the Registration District. The following table shows the annual deaths and death-rates from phthisis in Belfast itself since 1891, the rates being based on the figures published in the weekly "summaries" of mortality returns, and on population as estimated by the number of births registered (Table I., col. *c*.).

TABLE XVIII.—Showing for the City of Belfast the annual deaths and death-rates per 1,000 referred to Phthisis since 1891 :—

—	Deaths registered.	Death-rate per 1,000	—	Deaths registered.	Death-rate per 1,000
1891, ..	1,017	3·97	1899, ...	1,112	3·08
1892, ..	1,105	4·31	1900, ...	1,115	3·12
1893, ..	1,016	3·60	1901, ...	1,092	3·13
1894, ..	977	3·45	1902, ...	1,132	3·14
1895, ..	1,083	3·63	1903, ...	1,030	2·74
1896, ..	1,008	3·15	1904, ...	1,120	3·00
1897, ..	995	3·05	1905, ...	1,116	2·95
1898, ..	1,044	2·97	1906, ...	1,015	2·67

This table shows that there has been a fairly steady diminution in the mortality referred to this disease, and that this diminution first began to assume appreciable proportions after 1895.

We may next examine the incidence of phthisis mortality in Belfast on the two sexes, and on the different ages of the population in Belfast. For reasons already explained, when other causes of death were under consideration, such examination can only be made in respect of the years 1900, 1901, and 1902, from the special returns supplied to us by the Registrar-General for Ireland.

The results of this examination are very striking, as shown in the following tables :—

TABLE XIX.—Showing the number of deaths of males and females, at certain ages, which were ascribed to Phthisis in Belfast and in Manchester in three years (1900, 1901, and 1902).

—	BELFAST.			MANCHESTER.		
	Males.	Females.	Total.	Males.	Females.	Total.
0–5, ..	34	35	69	18	37	55
5–10, .	23	62	85	19	38	57
10–15, ..	59	103	162	31	49	80
15–20, ..	199	291	490	80	88	168
20–25, ..	235	299	534	153	156	309
25–35, ..	368	573	941	421	347	768
35–45, .	270	344	614	572	333	905
45–55, ..	153	135	288	501	210	711
55–65, ..	66	47	113	197	75	272
65 upwards,	13	10	23	68	31	99
All ages, ..	1,420	1,899	3,319	2,060	1,364	3,424

A cursory glance at this table is sufficient to show that the distribution of deaths referred to phthisis among the various age groups in Belfast was, in the particular period of three years, very different from that in Manchester.

Thus, in Manchester the bulk of the deaths, amounting to 70 per cent. of the total number, occurred between the ages 25–55, while, in Belfast, but little more than one-half of the deaths occurred at these ages. Moreover, at the ages under 25, about 40 per cent. of the total phthisis deaths occurred

in Belfast, while in Manchester the proportion did not reach 20 per cent. It may be added that in the case of London, for the year 1905, the corresponding percentages were 76 and 19 respectively.

The striking contrasts afforded hy these figures, however, are not fully apparent until the phthisis death-rates per 1,000 living at each age group are brought into account. These death-rates for the three years in question are set out in the table below for Belfast and Manchester; for Ireland in 1905, as published in the Annual Report of the Registrar-General for Ireland; and for England and Wales in the decennium 1891–1900, as published in the last decennial supplement of the Registrar-General for England and Wales.

The figures of this table are reproduced in graphic form in the annexed diagrams.

TABLE XX.—Showing for Belfast and Manchester, in the years 1900, 1901, and 1902; for Ireland in the year 1905; and for England and Wales in the decennium 1891-1900, the mean annual death-rates per 1,000 living referred to Phthisis at various age groups among persons of both sexes, and among males and females.

—	Under 5.	5–10.	10–15.	15–20.	20–25.	25–35.	35–45.	45–55.	55–65.	65 and upwards.	All ages.
BELFAST—											
Males, ..	·52	·41	1·17	3·81	4·83	4·46	4·83	4·05	2·85	1·05	2·93
Females, ..	·55	1·12	2·01	5·13	4·56	5·48	5·02	2·75	1·85	·58	3·38
Both sexes, ..	·54	·77	1·59	4·49	4·68	5·03	4·94	3·31	2·09	·78	3·17
MANCHESTER—											
Males, ..	·19	·23	·38	1·0	1·9	3·0	5·6	7·2	5·2	3·7	2·68
Females, ..	·37	·44	·60	1·0	1·7	2·3	3·2	2·9	1·6	1·1	1·62
Both sexes, ..	·29	·33	·49	1·0	1·8	2·7	4·4	5·0	3·2	2·1	2·10
IRELAND—											
Males, ..	·4	·3	·5	1·9	3·5	4·1	3·5	2·4	1·7	1·1	2·1
Females, ..	·4	·6	1·3	3·1	3·2	4·0	3·1	1·9	1·3	·7	2·1
Both sexes, ..	·4	·4	·9	2·5	3·4	4·0	3·3	2·1	1·5	·9	2·1
ENGLAND AND WALES—											
Males, ..	·44	·17	·23	1·00	1·89	2·37	3·10	3·14	2·62	1·31	1·58
Females, ..	·39	·24	·50	1·29	1·59	1·92	2·12	1·64	1·24	·67	1·21
Both sexes, ..	·41	·21	·37	1·14	1·73	2·14	2·59	2·36	1·88	·95	1·39

The table and diagrams show that for the three years 1900–1902 the death-rate in Manchester ascribed to phthisis was relatively low at ages under 35, and that it was relatively high at the ages over 35. In Belfast in the same three years almost the reverse was the case.

Similar contrasts are observed in the diagram depicting the incidence on ages of mortality from phthisis in Ireland in 1905, and in England and Wales in the decennium 1891–1900.

The diagrams show clearly, indeed, that, for the periods in question, although the manner of incidence of phthisis deaths on ages and sex is broadly similar in Belfast and in Ireland on the one hand, and in Manchester and in England and Wales on the other hand, this manner of incidence in the case of Belfast and Ireland is very different from that in the case of Manchester, and England and Wales.

But there is another striking feature of the table and diagrams in regard to the incidence of Phthisis mortality on sex.

BELFAST HEALTH COMMISSION.

PHTHISIS.

DIAGRAM I.

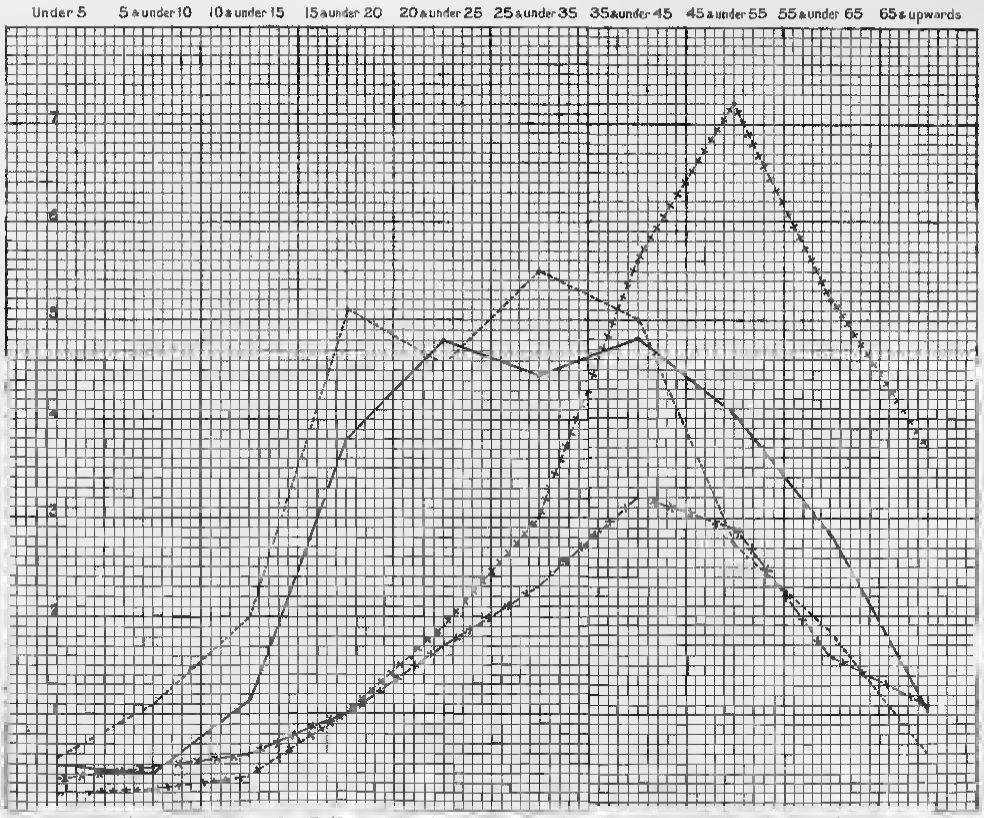

DIAGRAM I.—Showing for Belfast and Manchester, in the years 1900, 1901, and 1902, the mean annual death-rates referred to **PHTHISIS**, per 1000 living among males and females at 10 groups of ages.

Black Lines _____ = Belfast.

Black Lines _ _ _ _ _ = Belfast.

Black Lines +++++++ = Manchester

Black Lines -X-X-X-X- = Manchester

_____ = Males

+++++++ = Males

_ _ _ _ _ = Females.

-X-X-X-X- = Females.

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BELFAST HEALTH COMMISSION.

PHTHISIS.

DIAGRAM II.

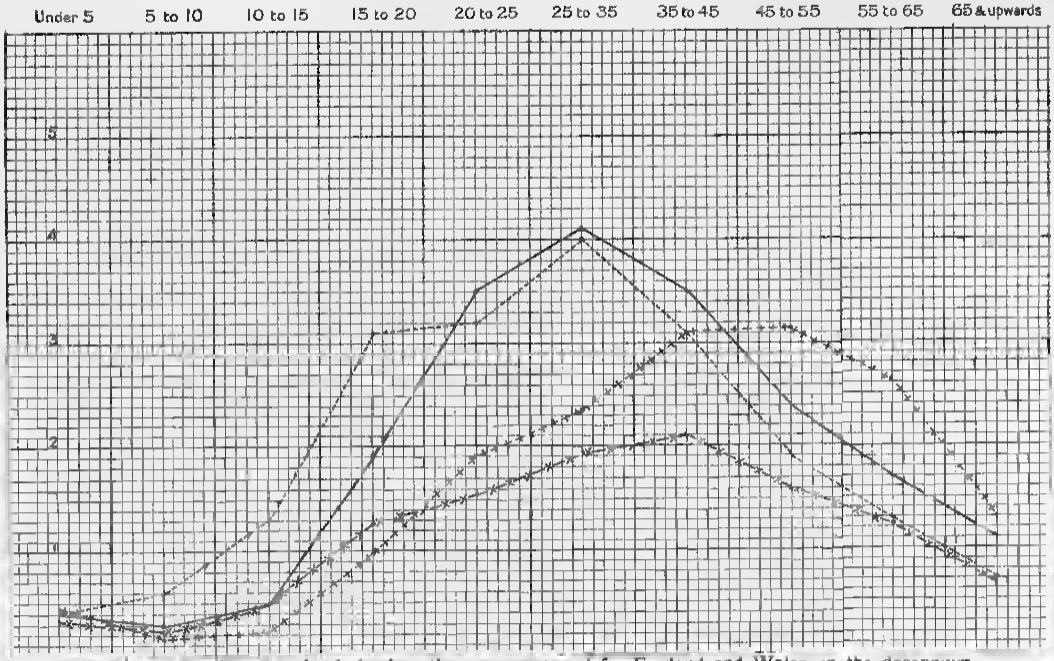

DIAGRAM II.—Showing for Ireland in the year 1905, and for England and Wales, in the decennium 1891-1900, the mean annual death-rates referred to PHTHISIS, per 1000 living among males and females at 10 groups of ages.

Black Lines ——— = Ireland.

Black Lines + + + + + + + + + = England and Wales.

——— = Males

– – – – – – – – – = Females

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In Belfast there appears to have been a marked excess of mortality among *females* over that among males at practically all ages between 5 and 35, while in Manchester there appears to have been a marked excess among *males* at all ages except those under 20.

The dissimilarities of the incidence of phthisis mortality on age and sex, indicated by the table and the diagrams, are in fact so great as almost inevitably to suggest that differences in the nomenclature of disease may account for them—that is to say, that in Ireland and in Belfast a large number of deaths at the younger ages may be attributed to Phthisis which in England and Wales and in Manchester are not so attributed.

Whether or not this is the correct explanation would of course be very difficult to determine. It is at least a consideration not to be lost sight of in any investigation of the subject of phthisis in Ireland.

In the case of Belfast, however, difficulty in accepting such an explanation as a complete one may be found in the fact that, as already shown, the death-rate from all causes, in the three years 1900-1902, was considerably higher at the younger ages in that city than in Manchester. It is natural to suppose that if, as matter of fact, mortality from Phthisis at the younger ages in Belfast had been a statistical fallacy due to differences of nomenclature of disease, such fallacy would have become apparent on dealing with the mortality from all causes at these younger ages. As, however, there was excess of mortality at the younger ages from all causes it might be inferred that such excess was due specifically to the excess at these ages of the mortality from phthisis. This inference obtains some confirmation from the following table which compares the difference between the mortality from all causes at the younger ages in Belfast and Manchester, with the corresponding difference between the mortality from Phthisis and that from other tubercular diseases. Analogous figures for enteric and continued fever are also included in the table.

TABLE XXI.—Showing for Belfast and Manchester the death-rates per 1,000 at certain groups of ages from (1) All Causes, (2) Phthisis, (3) Other Tubercular Diseases, and (4) Enteric and Simple Continued Fever, in the years 1900, 1901, 1902.

——	10–15.	15–20.	20–25.	25–35.	35–45.
All Causes—					
Belfast, ...	5·0	8·1	8·7	11·2	15·8
Manchester, ...	3·0	3·7	5·2	7·6	16·0
Difference, ..	2·0	4·4	3·5	3·6	—0·2
Phthisis—					
Belfast, ...	1·6	4·5	4·7	5·0	4·9
Manchester, ...	0·5	1·0	1·8	2·7	4·4
Difference, ..	1·1	3·5	2·9	2·3	0·5
Other Tubercular Diseases—					
Belfast, ...	0·9	0·5	0·3	0·3	0·3
Manchester, ...	0·3	0·2	0·2	0·2	0·2
Difference, ..	0·6	0·3	0·1	0·1	0·1
Fever—					
Belfast, ...	0·6	0·8	1·1	0·9	0·6
Manchester, ...	0·1	0·2	0·3	0·2	0·2
Difference, ..	0·5	0·6	0·8	0·7	0·4

It thus appears as though the excessive mortality at the younger ages from all causes in Belfast, as compared with Manchester, in the three years 1900–2,

may have been due mainly to the excessive mortality at those ages referred to phthisis, and partly also to that from other tubercular diseases and from enteric fever.

On the other hand, given an excessive death-rate from all causes at the younger ages, it might be contended that, if there has been any "terminological inexactitude" at all in referring deaths to "Phthisis" or "Consumption," there is not any reason for assuming that such inexactitude has not operated in relation to the excess of deaths at these younger ages. Indeed, it might be held that any inaccuracy as regards nomenclature of fatal illness might be expected to be more common in the case of children than in the case of older persons. From this point of view the following table is of interest :—

TABLE XXII.—Showing the *proportion* which the Phthisis death-rate at each age group over five years bears to the death-rate from All Causes, in both Belfast and Manchester, in the years 1900–1902, taking the All Causes death-rate at each age group in each town as 100 :—

——	5–10.	10–15.	15–20.	20–25.	25–35.	35–45.	45–55.	55–65.
Belfast, ...	12	32	55	54	45	31	13	4
Manchester, ...	6	16	27	35	35	27	18	6
Percentage excess of Belfast over Manchester.	100	100	104	54	29	15	—28	—33

This table shows that not only was the death-rate referred to phthisis at the younger ages much higher in Belfast than it was in Manchester, but, further, that the *proportion* of phthisis deaths to the deaths from all causes was also very much higher, at the younger ages, in Belfast than it was in Manchester. What is even more striking, perhaps, is that it shows that more than half the deaths which occurred in Belfast between the very early ages 15 to 20 were attributed to phthisis.

It seems highly improbable that such could have been actually the case.

Before any of the hypotheses suggested by the foregoing tables could be entertained, however, an exhaustive analysis would have to be made of all the main causes of death in Belfast in respect of age and sex incidence, as disclosed not only by the special mortality returns supplied to us, but also of analogous returns for other years. It is obvious that important inferences from the returns of three years only cannot safely be drawn.

Another question that arises is one that was suggested in the course of our sittings, namely, whether the excessive mortality referred to phthisis in Belfast could be due to industrial causes.

Evidence was given by Sir John Byers and Professor Lindsay which seemed to indicate that the excessive incidence of phthisis in Belfast might be due, to some extent, to the conditions of employment, but their data, in the regrettable absence of proper records of mortality to which we have had occasion so often to refer, were admittedly fragmentary. Had there been such records it would have been a comparatively simple task to classify deaths ascribed to phthisis according to the occupations which had been engaged in by the sufferers, and thus an important contribution to knowledge of this intricate subject might have been secured. But as matters stand it seems almost impossible to express any definite opinion on the matter.

Since, however, Belfast's record as regards phthisis is not exceptional for Ireland, and even shows signs of improvement which that of Ireland as a whole does not, and also since the incidence of that mortality on age and sex in Belfast

is broadly similar to that in Ireland as a whole, it might fairly be contended that it is not likely that industrial causes have played a very important part in conducing to this disease in Belfast. There is, however, one feature of the incidence of the pbthisis mortality on sex in Belfast which does appear to be exceptional, namely, the excessive incidence on females at the ages 25-35, and 35–45. (See Table XX and diagrams). In view of the large number of women employed in the various branches of the linen industry in Belfast, it may be that industrial causes have operated to conduce to the exceptional female phthisis mortality at these ages.

On the other hand, these and other remarkable differences in the age and sex incidence of mortality from this disease, which we have referred to above, may have other factors of far-reaching importance underlying them. In our opinion it is quite clear that the whole subject of pbthisis in Ireland as compared with that in England and Wales deserves further and exhaustive inquiry. An important branch of this inquiry should clearly comprise a minute investigation into the age and sex incidence of the mortality from the disease through successive quinquennia and decennia, not only in Ireland as a whole, but also in each of the various Irish towns, and in the rural districts. If this is done it may well be that information of essential importance will be obtained by way of ascertaining the causes of such incidence on age and sex: and if these causes are thus ascertained, it may turn out that much will have been achieved towards elucidation of the causes of that relatively excessive mortality from phthisis which is now such a conspicuous feature of Ireland.

As regards such administrative questions as the notification of phthisis, and the provision, out of public funds, of sanatoria and dispensaries for the treatment of phthisis, we do not think it necessary to make definite recommendations. They are among the questions which, as we have already observed, cannot be settled by reference to the circumstances of Belfast, apart from those of Ireland. Moreover, the Local Government Board for Ireland have advised local authorities on these matters in recent circulars, and we understand that the Chief Secretary for Ireland has intimated his intention to introduce a Bill in the present session of Parliament in regard to these questions.

(G) CEREBRO-SPINAL MENINGITIS.

During our Inquiry this disease was very prevalent in Belfast, and we took such evidence as was available regarding it

That evidence did not throw any light upon the causation of the disease except that it is often associated with poverty and insanitary conditions. We can only recommend that the circumstances of every case notified should be closely investigated and recorded by the Public Health Department, and that minute study of the disease, both clinical and bacteriological, should be patiently continued. We think that until more is known of the nature and causation of the disease, it is important that as many as possible of the cases should be treated at the Isolation Hospital, and that medical practitioners in Belfast should do their utmost to encourage the removal of cases to this hospital.

Section IV.

WATER SUPPLY.

The water supply of Belfast is under the control of the Belfast City and District Water Commissioners, who were incorporated under the Belfast Water Act of 1840, and have since controlled not only the water supply of the City but also that of some adjoining areas. There are fifteen Commissioners elected on the same franchise as the Corporation, and two *ex-officio* members—the Lord Mayor and the Chairman of the Harbour Commissioners. The Commissioners hold office for three years and retire in a body. Board meetings are held fortnightly, and there are three Committees—for Works, Finance, and Law, respectively.

The maximum powers of rating are :—

Domestic Rating, . . .	1*s.* 8*d.* in the £.
Public „ . . .	5*d.* „
Rating on Lands, . . .	2*d.* „

and the current rates are :— . . . 1*s.* 4*d.*, 4*d.* and 2*d.*

The charges for meter supplies for trade or other special purposes range from 5½*d.* to 10*d.* per 1,000 gallons.

The total borrowing powers of the Commissioners conferred by Acts 1840 to 1903 amount to £2,111,000.

The total capital expenditure of the Commissioners to 31st October, 1906, was £2,005,464 15*s.* 2*d.*, and the total debt then outstanding, £1,867,345, leaving a margin of borrowing power of £243,655. This margin, however, at 1st October, 1907, had been reduced to £68,655, and there were then undertakings in progress which will absorb about £40,000 of this balance.

In 1891 the total water revenue was £40,608.
In 1906 „ „ „ „ „ £96,400.
In 1891 the water consumption was 9½ million gallons.
In 1906 „ „ „ „ „ 14¾ „ „

The waterworks now in use were constructed under special Acts of 1865 and later years. The water now provided is obtained from three independent sources known as the Woodburn, Stoneyford, and Mourne areas.

Woodburn supply.

The Woodburn supply is the oldest, and served the town from about 1867 to 1890, when it was supplemented by the Stoneyford supply.

In 1901 an additional supply was obtained from the Mourne area.

The Woodburn area lies from 11 to 15 miles N.E. of Belfast, at an elevation of from 320 to 1,080 feet over Ordnance Datum, and has an extent of 6,937 acres. It contains a number of farms, some of which, however, only came into existence about 1875, when a large area of mountain pasture belonging to the Municipal Commissioners of Carrickfergus was broken up into farms. In 1851 Mr. Bateman described the Woodburn area as clean pastoral mountain land, but the Census returns show that between 1871 and 1901, 72 houses were built in the townland of Commons, which was formerly quite devoid of houses. Only part of this townland is in the catchment area.

The Woodburn area was selected after long discussion and investigation, and the Commissioners were advised regarding it by the late Sir Charles Lanyon, the late Sir John M'Neill, and the late Mr. J. F. Bateman. The Woodburn scheme was gradually developed, two storage reservoirs on the

Woodburn rivers, a conduit, and a service reservoir in Belfast being first constructed. Subsequently the works were added to, and at present the reservoirs comprised in the Woodburn system are as undernoted :—

	Capacity.
Lower South Woodburn,	107,250,000
Middle ,,	460,000,000
Upper, ,,	367,250,000
North Woodburn,	81,750,000
* Lough Mourne,	401,250,000
Copeland,	133,500,000
Dorisland,	66,250,000
Two service reservoirs (Old Park and Carr's Glen),	67,500,000
Ballyaghagan and Ballysillan service reservoirs,	1,250,000
Total storage capacity,	1,686,000,000 galls.

The Woodburn works are capable of supplying about 9,000,000 gallons per day on the average, representing the collection of 20¾ inches of rain out of a gross average rainfall of 44 inches. They are incapable of further extension, and, moreover, on account of the levels at which the conduit was laid in 1865, water from this source cannot be delivered by gravitation to a higher level than 170 to 180 feet over Ordnance Datum.

The total area of the Woodburn catchment is made up of two main parts, one of which has an area of 2,252 acres, and delivers into Lough Mourne and the Copeland reservoir. All water from Lough Mourne, which is a natural lake converted for use as a reservoir, passes through the Copeland reservoir and thence by an iron pipe and short conduit to the main Woodburn conduit at Dorisland. The other main portion of the catchment has an area of 4,685 acres, and delivers by the Woodburn rivers and artificial conduits into the North and South Woodburn reservoirs, which are discharged through the Dorisland reservoir into the main Woodburn conduit leading to Belfast. Storm waters can be diverted from the Copeland reservoir, but not from the Woodburn reservoirs, with the exception of the Dorisland reservoir.

The flow from a small portion of the catchment area known as the Frenchpark conduit area, with an extent of about 470 acres, can be sent to waste, or discharged into the Dorisland reservoir or directly into the main conduit from Dorisland to the filters at Oldpark, which is for the greater part of its total length of about nine miles a culvert 3½ feet in diameter of brickwork in lias lime mortar.

It is evident that water can be drawn from these reservoirs in a great many ways, but it was stated that care is taken to select from time to time that portion of the available supply which is in the best condition, and that the water is decanted from reservoir to reservoir. The total storage capacity of the reservoirs is about 180 days' supply at 9 million gallons a day, but there is reason to believe that a small portion of the supply may occasionally pass to the filters, from the Frenchpark conduit area, without passing through any storage reservoir.

It was stated that at times the supply from this system is drawn from the South Woodburn reservoirs, at other times a combined supply from the North and South Woodburn reservoirs is drawn, and that at other times the entire supply is taken from Lough Mourne and Copeland reservoirs to the extent of 6 million gallons a day. 1617–1620.

The Woodburn water supply was delivered unfiltered until February, 1894, when five filter beds were provided at Oldpark, Belfast. Two additional filters were afterwards provided and put in use in June, 1901. The total sand area of each filter is 3,804 square yards, and when six are at work—the other being out of use for cleaning—the total area of sand in use is 22,824 square yards.

* Lough Mourne, which is in the Woodburn district, County Antrim, should be distinguished from the Mourne Mountains catchment area in County Down

Since the introduction of the Stoneyford and Mourne supplies, the draught upon the Woodburn system has been reduced, and in recent years was stated to be under 6,000,000 gallons per day for nine months in the year, and to average 8,000,000 gallons per day for the remaining three months, so that the average rate of filtration is about 257 gallons per square yard per 24 hours for nine months and 350 gallons per square yard per 24 hours for three months.

The Woodburn water is supplied by gravitation to the town from a level about 190 feet over Ordnance Datum, and is confined to the lower parts of the city up to a level of about 160 feet over Ordnance Datum. During nine months of the year those areas receive a mixture of waters from the Woodburn and Mourne areas which at times approximates to equal proportions. The higher parts of the City in the Ardoyne and Crumlin districts were first supplied from a small high-level service reservoir at Ballyaghagan, which was constructed in 1876, and received water from springs at Whitewell up to October, 1884. Turbine pumps were then provided to supply it with Woodburn water. This latter arrangement existed until September, 1890, when the completion of the Stoneyford works made it possible to supply this district by gravitation. The turbine pumps were then removed. About 300 people are still supplied from the Whitewell springs.

16645. Since August, 1900, small high areas of the City, known as the Ligoniel and Ballysillan areas, which cannot be supplied by gravitation, have been supplied with Woodburn water pumped from the service reservoir at Oldpark into a small service reservoir at Horse Shoe at a level of about 600 feet over Ordnance Datum. The population in the Woodburn areas of supply is estimated at 258,500.

Stoneyford Supply.
16647. The growth of the City, especially in the higher districts, rendered it necessary to seek a supplemental water supply at a higher pressure than the Woodburn system could give, and by the Act of 1884 the Water Commissioners were authorised to construct waterworks in the Stoneyford district, which had been placed second to the Woodburn district by the late Mr. Bateman, and which Mr. Macassey, M.Inst.C.E., said was the best source of supplemental supply available to the Commissioners.

The Act of 1884 authorised the construction of the main Stoneyford reservoir, a conduit, a service reservoir at Lagmore, and the necessary distributing mains, and by the authority of an Act of 1889 a second storage reservoir was constructed in the adjoining Leathemstown area, mainly for the better regulation of compensation water awarded to millers.

The total catchment area which lies between 445 and 1,085 feet over Ordnance Datum is made up as follows :—

	Acres.
Stoneyford Reservoir area, ...	1,688
Stoneyford Conduit area, ...	1,950
Leathemstown Reservoir area, ...	1,710
Total, . .	5,348

from which, after providing compensation water, a supply of $3\frac{1}{2}$ million gallons a day is obtainable from the average annual rainfall of 35·65 inches.

The nature of the catchment area is similar to that in the Woodburn district, and is dealt with later on in this Report.

The area called the conduit area can only deliver into the reservoir when the water in it is at least eight feet under top water level. The storage capacity of the reservoirs is as follows :—

	Gallons.
Stoneyford Reservoir, ...	769,500,000
Leathemstown Reservoir, ...	99,500,000
Lagmore Service Reservoir, . . .	21,250,000
Total, . .	890,250,000

The average draught for town supply from these works in recent years has been under 3 million gallons per day, and the total capacity of the main reservoirs is equal to about 300 days' supply.

The water is drawn from the Stoneyford reservoir by a closed brick culvert to filters at Forked Bridge, about a mile below the reservoir, and is then conveyed by a similar culvert to Lagmore service reservoir, about 6½ miles below the filters, and about 5½ miles from the centre of Belfast. From the service reservoir the supply is given by two cast-iron mains 15 inches and 18 inches in diameter, at a head of about 350 feet over Ordnance Datum, to the higher parts of the city on the Antrim side between the levels of 160 and 300 feet over Ordnance Datum, with a population of about 93,000.

The Stoneyford supply was first brought into use in January, 1890, and until the first instalment of the Mourne supply was introduced in 1901, extended to high-lying portions of the City, on the County Down side, which are now supplied with Mourne water. The water was delivered unfiltered until June, 1892, when four filters were provided at Forked Bridge. Two additional filters were afterwards provided and put into use in March, 1903.

Each of the six filters has a sand area of 2,730 square yards, so that an area of 13,650 square yards may be taken as available at one time, and therefore, with a draught of 3 million gallons a day, the average rate of filtration would be about 220 gallons per square yard per 24 hours.

Mourne Supply.

In 1892 the Water Commissioners decided that a further supply of water was necessary, and after prolonged investigation a catchment area in the Mourne Mountains was selected, and powers for the acquisition of the necessary water rights, and of land for the construction of a reservoir in the valley of the Kilkeel River, were obtained by an Act of 1893. By an Act of 1897 power was obtained to construct another reservoir in the adjoining valley of the Annalong River, and by an Act of 1903 power was given to change the proposed site of the reservoir embankment in the Kilkeel valley. The whole of the waters of the rivers above the points of interception were acquired, and it was proposed to carry out the work by instalments, the first of which has been executed. This comprises weirs for the interception of the flow of the rivers, a conduit about 35 miles long to a service reservoir at Knockbrecken, about 5½ miles from the centre of Belfast, and the necessary mains to the City. The capacity of the service reservoir is 98 million gallons, and it affords a pressure of about 350 feet over Ordnance Datum.

The conduit was constructed as follows :—

With concrete work in cut and cover, . .	15·7 miles.
In tunnel, , ...	6·65 ,,
With pipes, ...	12·6 ,,

The pipes or syphon portions of the conduit have a carrying capacity of about eleven million gallons per day, but the remainder of the conduit has about three times that capacity. It is proposed that additional syphons shall be added at a future time, when required.

The area of the Mourne catchment is 8,724 acres, and all of it except 424 acres has been acquired by the Water Commissioners, and its elevation is from 440 to 2,796 feet over Ordnance Datum.

Water from the Annalong River was brought into use about September, 1901, and from the Kilkeel River in 1905.

During dry periods of the year, the Mourne supply is used solely for the higher areas, on the County Down side of the City, which have a population estimated at 37,500, and an average consumption of water of 1,930,000 gallons per day, but during the wet periods of the year the supply is extended into the Woodburn area of supply. During 1906 about six million gallons per day on the average were supplied to the City from Knockbrecken, to which reservoir the works furnished an average of about eight million gallons a day, the excess water being discharged at the waste weir of the reservoir.

In 1906 the average daily supply to the City was :—

From Woodburn,	. . .	5,878,720 gallons
From Stoneyford,	. .	2,913,439 „
From Mourne,	. . . .	5,930,020 „
	Total, . .	14,722,179 gallons.

Storm waters can be rejected at the intakes from the Annalong and Kilkeel Rivers.

The Mourne supply has no storage except that afforded by the conduit and service reservoir, and is not filtered.

In 1877 Mr. Macassey was instructed to report on the advisability of filtering the Belfast water supply, and stated that he was of opinion that filtration was necessary for the water then supplied from Woodburn. At this time, however, the storage capacity was much less than it now is, and the water from the reservoirs passed along the beds of the rivers for some distance before it entered the conduit. Filters were first introduced for the Woodburn supply in 1894.

According to the evidence of Mr. Richard Hamilton, Secretary to the Water Commissioners, the quality of the water supply had never been questioned until a report, dated November, 1898, on the epidemic of typhoid fever in that year was made by Professor Lorrain Smith. Professor Letts, however, appears to have drawn attention to the doubtful quality of the water according to chemical analyses not later than 1886.

Potential Sources of Pollution on the Catchment Areas.

The Mourne Mountains catchment area is an upland gathering ground of the highest class. It is uncultivated, and is free from human habitations. The whole area is owned by the Water Commissioners with the exception of a small portion in the Annalong valley, where some quarries are being worked, a considerable number of men being daily employed there. It is important that this small portion of the catchment area, situated as it is, not far from the main Annalong river, should be acquired by the Commissioners, if there is no possibility of diverting the water which flows from it.

The Stoneyford catchment area, on the other hand, supports a resident population engaged in farming. Until recent years the population living on the whole of this catchment area was estimated at about 750 persons, and the area under cultivation as distinct from that used as pasture was said to be some 2,240 acres, or about two-fifths of the whole. Most of this cultivated land was in the lower reaches of the catchment area, and therefore nearer the reservoirs than the pasture land.

Numerous streams and rivulets feed the main streams supplying water to the reservoirs, and into these, of course, the drainage from the cultivated land and from the dwellings must eventually pass. So far as we know, few of the dwellings are provided with proper means of drainage. For the most part, they are not provided with privy or closet accommodation, and slop waters find their way, after being cast upon the ground near the houses, into the nearest watercourse. In addition drainage from pigstyes, manure heaps, &c., frequently accompanies these slop waters.

The importance of the pollution which thus arises varies in individual cases within very wide limits. Sometimes the distance which has to be traversed by a given pollution along a ditch or other feeder of a main stream, and along a main stream itself before it reaches the reservoir is very considerable—a mile or more—but in some cases the connection between a given pollution and the reservoir is more direct, or would appear to have been so until recent years. The actual amount of pollution at any given spot varies considerably, but usually it is not great, for the dwellings and farms are widely scattered, and are seldom to be found in groups.

Nevertheless, it cannot be denied that although the amount and importance of the pollutions may appear small, if each individual instance be regarded by itself, the sum total of them must be considerable.

In the case of this catchment area the importance of these potential sources of pollution has been greatly enhanced in the past by the occurrence year after year for several years of isolated cases of enteric fever among the resident population. The Water Commissioners claimed that they did all in their power to prevent water, which could possibly be regarded as likely to be contaminated with drainage from houses invaded by fever, from passing into their reservoirs, and it is due to them to say that they have latterly shown great activity in this respect. But when the natural difficulties of the situation are considered, especially the facts that enteric fever is not usually recognised at its onset, and that cases probably occur in any endemic prevalence of the disease which are not recognised at all, it is clear that any efforts to prevent infective material from gaining access to the reservoirs were not likely to be altogether successful.

It is evident therefore that in this gathering ground there were potential sources of pollution, and also that infective matter may, from time to time, have actually succeeded in reaching the reservoirs.

The Woodburn catchment area is similar to the Stoneyford area, and also supports a resident farming population estimated to have comprised until recent years some 1,000 persons. The sanitary conditions of dwellings occupied by the people are similar to those already described at Stoneyford, but cases of enteric fever are not known to have occurred among them.

Prior to 1899 the Water Commissioners endeavoured from time to time to put a stop to some of the more gross pollutions of the tributary streams on these gathering grounds, and in some cases provided concrete manure pits and drains, but they had not only to contend against unwillingness on the part of farmers to make use of such appliances when provided, but also they were hampered, as they claimed, by defects in their legal powers to protect their water from contamination. We are inclined, however, to the opinion that they did not sufficiently exercise or test these powers.

In 1899 the Commissioners obtained an Act enabling them to acquire compulsorily certain scheduled portions of the Stoneyford and Woodburn catchment areas, comprising, roughly, all lands within about three quarters of a mile of their main reservoirs. They have largely exercised the powers conferred by this Act, though their action has been much hindered by the slow legal processes involved.

As regards the Stoneyford area, they obtained possession of 365 acres in 1901, 489 acres in 1902, and 180 in 1903, since which date they have acquired another 34 acres. In all 59 farms or portions of farms have been purchased, including 51 dwellings occupied by 194 persons, all of whom have removed elsewhere.

As regards the Woodburn area, 142 acres were acquired during 1900-1903, 723 acres were acquired in 1904, 356 acres in 1905, 768 acres in 1906, and 758 during the present year, while a further 427 acres have been acquired but have not yet been taken possession of. In all 174 farms or portions of farms have been acquired on this area, and a population amounting to 538 persons has been displaced.

The total cost of these purchases has amounted to about £250,000.

Quality of Belfast Water.

We may next consider briefly the quality of Belfast water. We had evidence of this from a bacteriological point of view, from Professor Symmers, Professor of Pathology, Queen's College, Belfast; Professor Percy Frankland, the Water Analyst of the Water Commissioners; Dr. Houston, Water Examiner of the Metropolitan Water Board; and Dr. Mervyn Gordon, Bacteriologist, St. Bartholomew's Hospital, London.

The two last-mentioned bacteriologists were consulted by the Water Commissioners in consequence of a report made in February, 1907, by Professor Symmers to the Belfast Corporation, and through them to the public, that two samples of tap water obtained in Belfast contained, in each case, a micro-organism which was "in every particular identical with the bacillus of typhoid fever" so far as he had, at the time of his report, been able to investigate its identity.

In their preliminary report to the Water Commissioners, Drs. Houston and Gordon stated that after subjecting Professor Symmers' bacillus to a variety of tests they were unable to confirm the opinion that it was the *Bacillus typhosus*. Professor Frankland expressed the same opinion, and indeed Professor Symmers himself, as a result of further investigation, came to the same conclusion. Drs. Houston and Gordon further stated in this preliminary report that they had failed to find the typhoid bacillus in any of the samples of Belfast water collected by them, and that, having examined the various waters as supplied to consumers for the presence of *B. coli*, they had failed to find these organisms in the Mourne water (10 c. c.), but had found them in both the Stoneyford and Woodburn waters.

In a second report Drs. Houston and Gordon dealt with the matter in greater detail; first, in regard to the quality of the water at the various sources. Their experiments showed that about one half of the samples taken from the feeding streams of the Stoneyford and Woodburn areas showed the presence of typical *B. coli* in 1 c. c., a result which they considered reasonably satisfactory for raw upland water. Samples from the Mourne Mountains sources revealed no coli-like microbes in 10 c. c.

They then dealt with the matter as regards the quality of the Stoneyford and Woodburn waters after storage, and showed that about half of the samples taken from the storage reservoirs also contained typical *B. coli* in 1 c.c. There was thus apparently no improvement in the quality of the water after storage, as judged by the *B. coli* test. Dr. Houston's explanation of this result was that, owing to the prolonged storage, the stored water was not comparable with raw water collected on the same day, and that the quality of the raw water collected may have been exceptionally favourable on the particular occasion when their samples were taken.

Drs. Houston and Gordon next showed the effect of filtration on the quality of the waters. Their experiments indicated that in the case of both Stoneyford and Woodburn waters, the total number of micro-organisms was reduced by about 95-99 per cent., and that with two exceptions, no *B. coli* was present in the filtered water in 10 c. c. These results they also regarded as reasonably satisfactory.

Lastly, in regard to the quality of water as supplied to consumers, they showed that no sample contained *B. coli* in 1 c. c., and that 19 out of 26 samples were free of the same microbe in 10 c. c.

Their general conclusion as result of their experiments may be quoted in full. "As stated in our first report, the presence of *B. coli* had admittedly a varying significance according to the source from which it is derived. Bearing this in mind, we consider that the results yielded by samples of the raw water are reasonably good for an upland water; and that the results given by the water after filtration, demonstrating as they do a large general diminution in its bacterial contents, imply in the present instance, a corresponding improvement in its quality for potable purposes, and therefore cannot be regarded as other than satisfactory."

In another report Drs. Houston and Gordon compared the quality of Belfast tap water, as judged by the *B. coli* test, with that of the water of some of the chief towns in England, Wales, Ireland, and Scotland. All the samples used for this comparative test were taken in April, 1907.

Excluding Belfast, 215 samples from twenty-six towns were taken, and of these 123 or 57 per cent. contained no typical *B. coli* in 100 c.c., while 92 or 43 per cent. contained these micro-organisms in 100 c.c. or in less. Twelve samples of Belfast water were taken, and of these 7 or 58 per cent contained no typical *B. coli* in 100 c.c., while the remainder contained these micro-organisms in that quantity. Drs. Houston and Gordon inferred from these

results that the quality of Belfast water compared favourably with that of the water of other cities. Though the number of samples of Belfast water examined for this purpose was necessarily small, it is to be noted that of the twenty-six samples taken on a previous occasion for the purpose of their second report 15 or 58 per cent. contained no typical *B. coli* in 100 c.c., a result which goes to confirm the result of the examination of the later samples.

In their last report Drs Houston and Gordon detailed experiments made by them to determine the vitality of the typhoid bacillus in Belfast water. For this purpose they used samples of Stoneyford and Woodburn water, before and after filtration in each case, and introduced into them enormous numbers of living typhoid bacilli. The samples were then stored in the dark. It was found that the typhoid bacilli which had been introduced into these samples rapidly diminished in numbers in a very short space of time. After a week the numbers had fallen from 10 millions to between 100 and 1,000 per c.c., and by the twenty-ninth day the bacillus could not be detected in either of the filtered waters, although for some time longer it could be detected in the unfiltered waters.

It might be inferred from these experiments that typhoid bacilli could exist for not longer than some thirty days in the great storage reservoirs at Stoneyford or Woodburn if they found access to them. It is probable, however, that under natural conditions the period of their existence in the reservoirs would be much less, for in the experiments the bactericidal effect of sunlight was excluded. In this connection Drs. Houston and Gordon point out that "experiments recently made in America under conditions more closely approximating to the natural conditions imply that decrease of the typhoid bacillus is much more rapid than under these more artificial laboratory conditions."

But it is evident from these experiments what an essential safeguard these great reservoirs, with a capacity for storage and settlement of water, extending as it does from 180 to 300 days, must have been to the safety of the Belfast water as supplied to the consumer.

Two other reports were submitted by Drs. Houston and Gordon dealing in some detail with the characters of the bacillus suspected by Professor Symmers to have been the typhoid bacillus, and with the views expressed by Professor Lorrain Smith in his report of 1898, in which he connected the prevalence of enteric fever in Belfast with the Stoneyford water supply. These need not be referred to further. They are reproduced in the Appendix together with the report on the experiments regarding the vitality of the typhoid bacillus in Belfast water.

Professor Percy Frankland, the official analyst of the Water Commissioners, also gave evidence. A number of reports made by him in past years were submitted to us, from which it appears that he had expressed views as to the Belfast water supply generally in accordance with those formulated by Drs. Houston and Gordon as result of their special experiments.

All these experts were unanimously of opinion that, notwithstanding the great improvements which have recently been effected at the Stoneyford and Woodburn gathering grounds, great and constant care in the storage and filtration of the various waters is called for, and that a bacteriologist should be engaged to make frequent observations.

The evidence thus adduced, as well as the inspections made by us showed that, although a great improvement has been effected in the Woodburn and Stoneyford catchment areas by the acquisition of all houses and lands within a distance of from half-a-mile to three-quarters of a mile from the reservoirs, there still remain in each catchment area potential sources of pollution which make it imperative that the supply from these areas should receive long storage and most careful filtration.

Little has yet been done to improve the quality of the water passing in the feeding streams from the higher lands not purchased, by irrigation on the lower lands acquired, and this matter should at once receive attention. Special care should be taken to remove a risk of pollution at the Copeland reservoir by drainage from the public road, and from some houses outside the area purchased. 8185–8191.

The total storage capacity of the reservoirs in connection with the Woodburn and Stoneyford works is equal to about 200 days' supply of the total yield of 12½ million gallons a day, but of course it is not practicable to ensure that all the water is stored for the same time. The average figures obtained by dividing the daily supplies in gallons by the number of square yards of filter area are satisfactory, but it appears from the evidence that the limits of rates within which the individual filters work are very wide indeed, and that occasionally a rate of as much as 800 gallons per square yard per day is reached at the Oldpark filters, where the area of sand is less in proportion to the supply of water than at Forked Bridge. It is right, however, to say that until recent years such a rate was considered to be not excessive. Having regard to modern investigations and to the necessity admitted by all the expert witnesses for very careful treatment of the Woodburn and Stoneyford waters, steps should be taken as soon as possible to secure uniformity of working of individual filters, as was recommended more than once by Professor Percy Frankland. The best means to ensure this requirement should be carefully considered by the Engineers of the Water Commissioners, aided by a bacteriologist.

Hitherto since 1898 the Belfast water supply has been analysed quarterly by Professor Percy Frankland, and his special reports made from time to time contain much valuable information and advice. It is to be regretted that the advice they contain has not been more fully attended to, and we are of opinion that it is necessary that in future the filtration works should be managed in full accordance with what modern knowledge shows is necessary, including—

(*a*) The use of fine sand of a standard size in the upper layers of the filters for a depth of at least 12 inches.

(*b*) The use at all times of as great an area of sand as can be made available.

(*c*) The prevention of unduly rapid filtration by the use of improved regulating apparatus capable of fine adjustment.

(*d*) Bacteriological control of the results of filtration.

The possibility of the passage of unstored water to the filters and of unfiltered water into the filtered water reservoirs or mains should be excluded.

We believe that much care is taken to send down from the storage reservoirs that water which is deemed to be in the best condition for supply, but we are of opinion that regulations regarding this important matter should be prepared by the Engineers of the Commissioners, who have now considerable experience enabling them to prepare such rules.

The question whether or not the Water Commissioners should have abandoned the older catchment areas and developed the Mourne Scheme more rapidly than was at first intended has been carefully considered by us. We are satisfied that the Mourne Scheme was not intended to be a substitute for the older waterworks, but merely to supplement them, and we are of opinion that the Commissioners have acted not unwisely in their policy in recent years. Evidently their hands were greatly tied by imperative financial considerations, and in deciding to maintain and improve the older waterworks they were guided by expert advice of the highest kind.

The early development of the Mourne supply should be the main feature of future policy.

The evidence regarding the Woodburn and Stoneyford supplies does not, in our opinion, justify their condemnation, but it certainly establishes the necessity for very careful treatment of those supplies.

We have carefully considered the question whether it is desirable that there should be a separate authority to control the water supply of Belfast.

We are of opinion that, although the Water Commissioners have done much excellent work, the water supply of Belfast should be in the hands of the Corporation, and base this opinion on the following grounds :—

(1.) That water supply is essentially a matter which should be administered by the authority responsible for the public health. The experience of Belfast as regards enteric fever furnishes a strong practical reason in favour of this principle. If the Corporation had been fully aware of the distribution of the water, and if the Water Commissioners had been fully aware of the distribution of the disease—in other words, if there had been one body instead of two—it is difficult to believe that serious question could ever have arisen that the water had played a prominent part in the production of enteric fever in the city.

For other practical reasons, also, it should be managed by the authority which controls the streets of the city and the erection of buildings, as with such single control there would be a clearer and less divided responsibility as to sanitary conditions, and a more convenient and economical discharge of official duties, than is now possible, could be secured.

(2.) That while the financial powers of the Water Commissioners are strictly limited the Corporation have wider financial resources.

(3.) The multiplicity of elections leads to reduced interest being taken in them, and increases the difficulty of securing the best men for the direction of public affairs.

It is interesting to note that in connection with the inquiry held in 1859 by a Royal Commission into rating questions at Belfast, the report stated—"We are of opinion that it is desirable that the duty of supplying the town with water and the exercise of the powers necessary for that purpose should be imposed on and entrusted to the Corporation of Belfast." "We recommend that the Water Commissioners should be consolidated with the Corporation of Belfast."

Section V.

MAIN DRAINAGE.

Main Drainage Act, 1887. Provision of Works.

Until the main drainage works, authorised by the Belfast Main Drainage Act of 1887, and carried out between 1888 and 1895, were completed, the sewers of the city discharged into the River Lagan, either directly or by contributory streams, but now discharge into intercepting sewers which convey the sewage to outfall works situated on land reclaimed from the Lough between the mouth of the Lagan and the Antrim shore, about two miles below Queen's Bridge. Practically the whole of the area comprised in the city before the extension in November, 1897, is now sewered to this outfall, and a portion of the added area on the County Down side also discharges sewage in this direction by the Knock Valley sewage system, constructed by the Belfast Rural Sanitary Authority before 1897. Large portions of the added areas, including Belmont, Sydenham, on the south, and Greencastle on the north, are, however, still incompletely sewered, and such sewers as exist discharge on the foreshore at various points. Intercepting sewers are now, however, being constructed for the Greencastle district, which will discharge to the main outfall, and plans have been prepared for intercepting sewers and separate outfall works at Sydenham, to which it is proposed to discharge all the sewage from the Knock and Sydenham district. It is also proposed to divert to these works the sewage of a portion of the old city area in Ballymacarrett, which at present is carried to the main outfall. When these works are completed the whole of the sewage of the extended city, excepting that of a few small areas, will be sent to two outfalls in tidal waters.*

The Main Drainage Act of 1887 definitely specified the course of the high level and outfall sewers, the construction of such low level sewers and works as might be necessary for intercepting and diverting to the outfall works all sewage flowing into the River Lagan and the Victoria Channel through the sewers of the Corporation, which were not intercepted by the specified high level sewer, and also directed the construction of a sewage storage tank at the outfall works of a capacity of 5,000,000 gallons.

The Act provides that—

> "It shall not be lawful to discharge sewage into Belfast Lough by means of the authorised works, except between the commencement of ebb tide and thirty minutes after half ebb tide at the point of discharge."

It, however, permits the discharge, after or in time of heavy rain, of water which may contain sewage matter by means of any storm outfall or overflow.

Corporation Act, 1899. Purification of Sewage

By Section 43, Sub-section 6, of the Belfast Corporation Act, 1899, it is enacted that—

> "The Corporation shall, within three years from the passing of this Act, provide works and appliances necessary for the proper purification of the sewage of the City of Belfast discharged from the system of works authorised by the Belfast Main Drainage Act, 1887, and shall efficiently work the same."

It further provides that—

> "The system of treatment and method of putting the same into operation adopted by the Corporation shall be subject to the approval of the Local Government Board."

A system of intercepting sewers was designed about thirty years ago by the late Mr. Montgomery, City Surveyor, but was not carried out. The system finally adopted in 1887 generally resembled the earlier design, except that in Mr. Montgomery's scheme two outfalls were proposed, one on each side of the river at the Twin Islands, while by the works as executed sewage from both sides of the river is conveyed to the one outfall on the Antrim side.

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*In Ballygomartin, a somewhat detached portion of the city, comprising about 100 houses, purification works, consisting of Dortmund tanks and sprinkler beds, have been designed with an ultimate capacity for about 300 houses, and one-half of these purification works are now in operation.

The sewage from the County Down side of the city now passes under the Lagan by syphons into the main low level sewer, which runs for a length of about 3⅞ miles from the southern boundary of the old city at Loughview-road to No. 1 pumping station at Duncrue-street by a course roughly parallel to and close to the river.

The size of this sewer varies from 2 feet in diameter to 7 feet in diameter between Loughview-road and the Milewater River, and is then 8 feet in diameter to the pumping station, with a gradient of 2 feet in a mile. The level of the invert of this sewer falls from 11·75 O.D. to 1 foot below O.D., 16791
and its sectional area and gradients vary considerably. According to the evidence of the City Surveyor, its lower length, when flowing 6 feet deep, can carry all the discharge the upper portion can send down, namely, 8,114 cubic feet per minute, or 73,026,000 gallons per day.

The area served by the low level sewer is 2,051 acres, including 1,030 acres on the County Down side, and the total population of the whole area is estimated at 154,000.

The capacity of the low level sewer represents a rainfall discharging from the whole area at the rate of about 1-15th of an inch per hour, and otherwise represents more than 15 times the average dry weather flow of sewage at 30 gallons per head per day.

The high level intercepting sewer, which is about 3 miles long, starts from University-road, opposite Lower Crescent, and is carried by Sandy-row, Donegal-road, and Matilda-street to Dunville distillery; thence by Distillery-road, Grosvenor-road, Cullingtree-road to Pound-street, up to which point it is 4½ feet in diameter. From Pound-street it is carried along Barrack-street, Millfield, Upper Library-street, Carrick-hill, and North Queen-street to Limestone-road, with a diameter of 6 feet, and then from this point to the No. 1 Pumping Station at Duncrue-street it has a cross-section of 8 feet by 6 feet 3 inches, and a gradient of 2 feet to a mile. The level of the invert of this sewer falls from 19·2 O.D. at Lower Crescent to 10·2 O.D. at No. 1 Pumping Station. From No. 1 Pumping Station the high level sewage and the sewage pumped from the low level trunk sewer is carried to the outfall sewer 10½ feet by 7½ feet, with a discharging capacity of about 15,000 cubic feet per minute.

The discharging capacity of the lower portion of the high level sewer is about 8,300 cubic feet per minute, and the area served by it is 2,673 acres, with an estimated population of 210,000.

The capacity of the sewer above stated is equal to a discharge of fully one-twentieth of an inch of rain per hour from the whole area, taking it as all impervious; but the City Surveyor said that only about 60 per cent. of the rainfall would reach the sewers as the area is largely suburban, and that the sewer could in practice deal with a rainfall at the rate of one-twelfth of an inch per hour. The capacity of the sewer may be otherwise expressed as equal to a flow of 74,862,000 gallons per day, or nearly twelve times the average dry weather flow of sewage from the population of 210,000 at 30 gallons per head per day.

The capacity of the pumps at Duncrue-street is 9,000 cubic feet per minute, or 81,000,000 gallons per 24 hours, and at No. 2 Pumping Station the capacity of the pumps available for pumping the sewage from the whole city to the storage tank is 3,520 cubic feet per minute, or 31,680,000 gallons per 24 hours.

Although the joint discharging capacity, viz., 16,462 cubic feet per minute, of the main intercepting sewers, is less than that of those designed by Mr. Montgomery, which appears to have been 18,250 cubic feet per minute, the City Surveyor stated that the sizes of the sewers are as ample as are usually found in large cities. He also stated that, if he had been designing the scheme, he did not think generally he would have put in sewers of larger capacity, but that he would have divided the districts into zones for the discharge of storm water, and provided suitable pumping stations to deal with any flow in excess of six times the dry weather flow at times when ordinary storm overflows are closed on account of high tides.

The system of intercepting sewers is, however, insufficient for the work thrown on it at present in time of heavy rain, on account of—

(1.) The increase of the city area;

(2.) The inadequacy of nearly all the storm overflows at times of high tides in the River Lagan, or high floods in the River Blackstaff;

(3.) The entrance of storm water from areas outside the city.

The central portion of Belfast, comprising the older parts of the city and the principal business quarters, is generally flat, rising only slightly over the level of high spring tides, and at some places lying below that level.

The city is subject in times of exceptional rainfall to flooding, which affects an area of considerable extent near the Great Northern Railway Station and other smaller areas. The flooding is mainly due to the insufficiency of old stream channels such as the Blackstaff river and Pound Burn, which have been modified and constricted by building operations, the erection of weirs for manufacturing purposes, and the construction of bridges with inadequate waterway.

The greater part of the flood water affecting the area near the Great Northern Railway terminus comes directly by overflow from the streams, but in the other areas subject to flooding a part of the water emerges from the sewers when they are gorged by storm water and the storm overflows are blocked by high tides. Evidence was given that the basement of a building near the City Hall is "constantly flooded at high tides."

Some of the sewers near the markets were stated by the City Surveyor to be of insufficient capacity for the discharge of heavy rainfall on the area to which they belong, and it is evidently necessary to provide a storm water pumping station in this neighbourhood to relieve the sewers, as proposed by the City Surveyor.

We were informed that the difficult questions as to how the main intercepting sewers can be relieved in time of heavy rainfall, and how the flooding of areas in the city may be prevented, are engaging the attention of the City Surveyor, and we recommend that these allied matters should be effectively dealt with as soon as possible, as the effect of the floods is undoubtedly very detrimental to the city generally, and specially injurious to the inhabitants of the flooded areas.

We are of opinion the proposal to divert a large part of the storm waters of the Blackstaff river by a tunnel carried from a point near the junction of the Blackstaff river and Clowney Water river to the Lagan is a good one, but in addition we consider the weirs in the Blackstaff river and Pound Burn should be removed, and the channels rectified and improved, so as to be as free and easily maintainable as possible. A good form for such stream beds in a city area is a semicircular channel with smooth slopes of concrete or paving rising from the edges of the channel. By Section 24 of the Belfast Improvement Act, 1847, the Corporation is specially empowered to deal with weirs and other obstructions which are likely to prevent good drainage.

Sewers.

According to the evidence of the City Surveyor a great many of the old sewers have been taken up and relaid from time to time, but many still require improvement. The amount expended per annum for this purpose during the past five years averaged about £2,200. He stated that there are many old sewers of which the dimensions could not be got because they are not on any plans, that many old sewers had no manholes on them, and that deposits are frequently found in old sewers which have had the flow in them reduced by the execution of the main drainage works.

For the purposes of Professor Lorrain Smith's Report of 1903, a special examination as to the condition of sewers in certain areas was made in 1901, with the following results. In one district, with an area of 10A. 1R. 2P. and an average elevation of 3 feet over high water level, the sewers, varying in size from 9 inches to 42 inches, were examined at twenty-seven openings, and the state of repair was found to be "good" at twelve points, "fair" at twelve points, and "bad" at three points, and deposit varying in depth from 4 inches to 14 inches was found at fourteen points. In this area tests applied to the

house drains showed that at least 33 per cent. were "defective." In a second district, with an area of 16A. 3R. 21P. and an average elevation of 99 feet over high water, the sewers, varying in size from 9 inches to 20 inches, were examined at fourteen points, and found to be in good order, and free from deposit at all the points of examination. In this district the smoke test proved that 73 per cent. of the house drains were "defective." In a third district, with an area of about 15 acres and an average elevation of 10 feet over high water, the sewers, varying in size from 6 inches to 30 inches, were examined at seventeen points, and the state of repair was found to be "good" at fourteen points, and "bad" at three points. Deposit was found from 3 to 17 inches in depth at eight points. In this area at least 32 per cent. of the house drains were "defective." In a fourth district, with an area of $12\frac{1}{2}$ acres and an average elevation of 10 feet over high water, the sewers, varying in size from 9 inches to 66 inches, were examined at twenty-six points, and the state of repair found "good" at twenty points and "bad" at six points. Deposit varying in depth from 4 to 10 inches was found at fourteen points. In this area at least 47 per cent. of the house drains were defective. In a fifth district, with an area of $65\frac{1}{2}$ acres and an average elevation of 160 feet over high water, the sewers, varying in size from 9 inches to 30 inches, were examined at thirty-four points, and the state of repair found "good" at all the points of examination. These sewers were also found free from deposit.

It is regrettable that the terms "good," "fair," and "bad" used in the report on this investigation are not defined, and that no other information in detail as to the condition of the sewers in the city was obtainable. The information obtained in those special areas, however, supports to some extent the opinion expressed by the City Surveyor already mentioned, and in our opinion indicates that the Corporation should, as soon as possible, have a complete survey of the condition of the existing sewers effected.

Evidence was given by several witnesses as to nuisance from the ventilation of sewers at the surface of the streets. The City Surveyor and Superintendent of Works stated that when complaint of such nuisance is received flushing and disinfection are carried out, and that the Surveyor takes such steps as are practicable either to close the surface ventilator or to do some other remedial work.

We consider that special care should be taken to remove grounds for complaint as to surface ventilation of sewers—

(*a*) By systematic flushing of all sewers with flat gradients.

(*b*) By the division by flaps of steep sewers into moderate lengths, separately ventilated.

Section VI.

SEWAGE DISPOSAL.

Part I.

Until about the year 1893 the sewers of Belfast discharged into the River Lagan, which was then in a very foul condition.

New main drainage outfall, 1893.

By the new main drainage system these sewers, as already stated, were intercepted by high and low level mains converging to an outfall in Belfast Lough about two miles seaward from Queen's Bridge, where the sewage is stored in a tank of five million gallons capacity, with the intention of limiting the discharge to a period from the beginning of ebb tide to half an hour after half ebb. This new outfall came into operation at the end of 1893.

Sewage discharged crude.

For fourteen years therefore from that date, the sewage of a population, at first of about a quarter of a million, and at the present time of about 360,000 people, has been discharged crude into the Lough at the present outfall.

But the increase in the volume of sewage discharged in recent years has been greater than the increase in population would indicate, for in 1893 Belfast had a great many privies, while now it is almost entirely a water-closet town.

Dry weather flow 15 million gallons.

The present sewage flow in dry weather is estimated by Mr. Cutler, the City Surveyor, at fifteen million gallons. Since 1901 there have been at work some experimental bacteria beds capable of dealing, it is said, with one-sixth of the sewage, but these have latterly been at work irregularly, and were recently out of operation.

Intention to discharge beyond West Bank.

The intention of the designers of the new main drainage system was, no doubt, that the sewage should be discharged beyond the "West Bank" into permanent water through the wooden shoot, nearly a mile long, which they provided. (See map of Lough).

But this wooden shoot seems to have been of faulty construction, and as early as 1897 was said by Mr. Giles, Harbour Engineer, to have been very leaky, and liable to frequent bursts; a result, no doubt, due to the slow rate of flow through this long flat conduit which led to deposit and choking. During the last two years the Corporation have been endeavouring to clear the shoot; and after clearing the deposit for some distance from the city end, several attempts have been made, by closing the openings which had been used for clearing, to force out the remainder of the deposit, but in each case the attempt has ended in another burst. The cleansing of the remaining part is proceeding, but as deposit is necessarily continuing, there is little prospect of better conditions being secured without an entirely new construction, or the substitution of other arrangements. No doubt there would be less difficulty if only settled sewage were passed through.

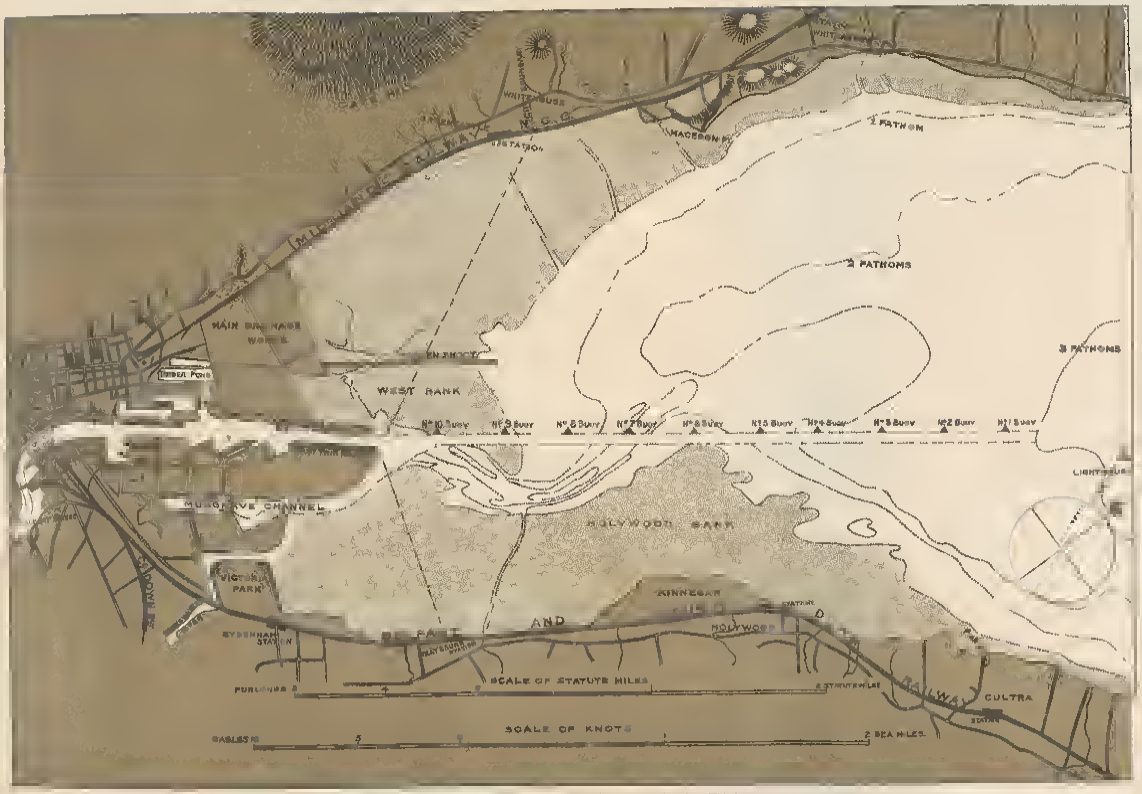
Discharge actually over the West Bank owing to failure of shoot.

It is evident, therefore, that only for a very few years after the completion of the main drainage scheme did the Belfast sewage wholly discharge where intended, into permanent water beyond the West Bank; and that since 1897 —that is for the last ten years—sewage has been largely discharged, through bursts and various leaks in the shoot, over the West Bank slob lands. It is unlikely that with large intermediate openings in the roof of the shoot, there should have been any appreciable flow through the partly choked outlet.

Discharge outside permitted hours.

The discharge of sewage has by no means always been limited to the permitted hours, owing to the inadequate capacity of the storage tank. Even a small amount of rain suffices to bring about a discharge which, if

BELFAST LOUGH.



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(The Lighter Shading indicates the Sloblands exposed at Low Tide.)

it be before high tide, leads to the sewage being drifted towards the timber ponds and the upper end of the Lough and the shore.

Character and strength of Belfast sewage

No systematic analyses seem to have been made to determine the character and strength of Belfast sewage. In his report of 1907 to the Corporation of Belfast on the question of Sewage Disposal, Professor Letts has given the result of such analyses of the sewage as he has made, and he states that "the actual amount of free ammonia in Belfast sewage is probably on an average about 2½ parts per 100,000 while that of albumenoid ammonia is somewhat less than half that quantity (viz., 1·25 per 100,000), and the ratio of the two may perhaps be taken as 1:0·4." However, in the table opposite page 56 in that report the average of the six samples of crude sewage there given is 1·94, say, 2 parts per 100,000 for free ammonia, and 1·24 parts per 100,000 for albumenoid ammonia.

In three out of these six samples the quantity of suspended matter varied from 31 to 41 parts per 100,000. It is obviously unsafe to rely on such limited data, and judging from the analogy of other large towns, and keeping in view the large amount of suspended matter brought down by storm waters, it is probable that the average of suspended solids in Belfast sewage will be found to be not less than 30 grains per gallon, or 43 parts per 100,000.

This would mean about 1·91 tons dry matter or 19·1 tons of sludge per million gallons. The experience of other places shows that in dealing with five dilutions of storm water or six volumes in all, the total amount which passes to the outfall in a year, exceeds that of the average daily flow by 50 per cent. If the total daily average of Belfast sewage is taken at 15 million gallons, this would give 22½ million gallons including storm water, and would represent 22½ x 1·91 tons or about 43 tons dry matter and 430 tons of 90 per cent. sludge per day.

It is expected that when the projected Sydenham works are in operation only 12 million gallons of sewage will come daily to the present outfall. This volume, with 50 per cent. addition for storm water, will give an average of 18 million gallons per day, carrying 34·4 tons dry matter and 344 tons of sludge per day. At Dublin, where a process of precipitation has recently been started, we found that in the three months preceding our visit in August, 1907, an average of 300 tons of sludge per day had been barged to sea, from a population of about 250,000 people now connected to the main outfall.

Trade effluents are received into Belfast sewers, apparently without condition or regulation of any kind* The chief industries of the city, flax spinning and weaving, and shipbuilding, do not produce any appreciable volume of trade effluent, but on the other hand the extensive local distilleries do produce a large volume of waste liquids which are very foul, and the organic impurities of which are immensely greater than those in a similar volume of sewage. In addition there is no doubt a considerable number and variety of trade effluents passing to the sewers or the streams, but their volume relatively to that of the domestic sewage is probably not large.

The River Lagan itself is now free of local impurities, except such as are brought down by the Blackstaff and other streams; and the nearest town up the river beyond Belfast is Lisburn, a place of 11,500 inhabitants, nearly ten miles away, where sewage purification works are now provided.

Configuration of the Belfast Lough.

By the construction of the Victoria Channel many years ago, the river Lagan was made to deliver into the Lough between the "Twin Islands," where it has a width of about 2½ miles, leaving on either side back-waters; that on the north reaching back to the Main Drainage Works and the Timber Ponds and the mouth of the Milewater stream, while that on the south reaches back to the mouth of the Connswater stream and the reclaimed lands forming the Victoria Park.

* See 3rd Report of Royal Commission on Sewage Disposal—"Trade Effluents," 1903.

The Main Drainage outfall shoot is to the north of the Victoria Channel, and extends about a mile seaward from the storage tank, but the actual delivery of the sewage, as we have seen, is now largely on the slob lands of the West Bank about ½ mile to the north of the outlet of the Victoria Channel.

Width of estuary and sluggish current.

In considering the effect of the mixed discharge of domestic sewage and trade effluents on the bed and waters of the Lough, it is important to note not only the width of the estuary at the point of discharge, which is about 2½ miles, but also the sluggish character of the currents.

The float experiments detailed in Professor Letts' report of 1907 go to show that the tidal currents on either side of the navigation channel do not exceed from ¼ to ⅓ knot per hour, while the current in the channel beyond the mouth of the Lagan and between the buoys is given as at most one knot per hour.

These experiments also indicate that sewage discharged at the main outfall at the best moment, just on the beginning of the ebb, would scarcely reach the Lighthouse, 3½ miles away, before it is carried back by the returning tide; and that a large part of the discharge would be met by the flood tide before it has travelled more than ½ mile to 1½ miles from the outfall, while the frequent discharge which takes place before high water, on account of the inadequate capacity of the storage tank, would be at once carried back towards the shore of the upper end of the Lough.

Local deposit of suspended solids.

In consequence of the very sluggish flow of the tides in this part of the Lough, it is probable that the bulk of the suspended matter in the Belfast sewage is rapidly settled on the slob lands near the outfall. This is confirmed by examination of these banks and shores, for they reveal serious contamination, evidenced by the presence of a considerable depth of black putrefying matter. For the same reason it seems unlikely that the south shore of the Lough from the mouth of the Connswater to Cultra can be affected by solid matter derived from the sewage discharged from the main drainage outfall; and, although some of the solids deposited on the northern slob lands may be later washed seaward and towards the navigation channel, it is probable that the quicker current of this channel prevents such deposited matter from passing to the south side of the Lough.

Relatively slow transformation of suspended matter.

It is important to remember that the transformation of deposited suspended matter is very much slower than that of dissolved impurities, and that while the transformation of dissolved impurities in large dilutions of sea water is aerobic and inoffensive, that of the matter deposited as mud on the banks and shores is mainly anaerobic, giving rise to serious nuisance.

Only the lighter and finely divided portions of the suspended matter, together with the dissolved impurities, stand any chance of being carried far seaward; and as to the dissolved impurities, it seems clear that they must in the circumstances of Belfast Lough, be subjected to considerable dilution with sea water.

Extent of dilution.

The extent of this dilution is an important element in the process of self-purification effected in the waters of the Lough, but it is difficult to estimate it. If it be assumed that there is an average fall of 8½ feet in the tide water level over a width of two miles, and that the average travel of the sewage is not more than 1½ miles, there might be a theoretical dilution of 600 to 1. It is quite unlikely, however, and indeed impossible, that there would be equal dilution over the whole mass of the ebbing and returning water, and the dilution reached in one tide will in reality be certainly much less.

A rough estimate of the dilution may be obtained by comparing the amount of free ammonia and of albumenoid ammonia in the six series of samples of Lough waters of which the analysis is given in Professor Letts' report of 1907, with the amount of the same matters in the crude sewage samples given in the same report at p. 56; and this comparison indicates a dilution varying according to the situation of the sample of from 30 times to 166 times. It is evident that the dilution of the dissolved impurities is very considerable.

No doubt, too, there is furtber dilution with each succeeding tide in the seaward movement, and as there is also a process of purification taking place by contact of the dissolved sewage impurities with the dissolved oxygen in the sea water, while tbe suspeuded impurities are left behind on the slob lands of the northern shore of the Lough, it seems very unlikely that any of the impurities of the Belfast sewage, whether suspended or dissolved, can ever reach the sea at all.

Are the natural purifying powers of the Lough waters able to deal with untreated Belfast sewage?

It is necessary now to consider how far the natural purifying capacity of the Lough waters is sufficient to deal continuously with the large and growing discharge of Belfast sewage; how far the amount of dissolved oxygen withdrawn from the Lough waters by the oxidation of organic impurities is recovered in the course of a tide.

Dissolved oxygen in Lough waters.

The investigations of Professor Letts described in his 1907 report to the Corporation, though not sufficiently extended to be conclusive, are of much service in connection with this part of the inquiry. In connection with most of the samples of the Lough water which Professor Letts has analysed, he estimated the amount of dissolved oxygen in them both at the time of collection, and also after they had been kept for some days; and he shows how, in the kept samples, the amount of dissolved oxygen is gradually reduced or taken up, in proportion to the organic impurities carried by the sample. This is presumably what takes place in the Lough, and it is desirable to ascertain whether these waters are able to recover their dissolved oxygen by contact with the air, by the disturbance of tbeir surface by wind, and by the oxygen production of marine plants, especially the *Ulva Latissima*, which is referred to later in our Report.

In the case of samples taken on the ebb tide in the path of the sewage discharge, tbe dissolved oxygen in the mixture of sewage and sea water was from 30 per cent. to 60 per cent. below that whicb uncontaminated sea water would contain at the same temperature. On the otber hand, in the case of the set of samples (series No. 6) taken on a line from Macedon Point to Holywood, about $1\frac{1}{2}$ miles beyond the point of discharge, it was found that the average of dissolved oxygen in the eight samples at the time of collection was 5·60 c.c. per litre, or only 2 per cent. less than tbe saturation point for sea water at the same temperature.

Other samples, however, taken at or beyoud the Lighthouse, two miles further seaward (series No. 1, samples 1 and 3), averaged 5·90 of dissolved oxygen, which is about $6\frac{1}{2}$ per cent. less than the theoretical figure, for the temperature of the day upon which these samples were taken. The data at our disposal are insufficient to warrant definite conclusions, and it would, no doubt, be advisable to take a number of samples of the Lough waters in mid-channel about three miles further seaward, say, on the line from Cloghan Point to Bangor, in order to ascertain what are the normal conditions in these waters as regards dissolved oxygen, free ammonia, and albumenoid ammonia.

But taking into account the continuous discbarge of untreated sewage which has been going on for so mauy years, it may be inferred from tbe data given that there is evidence of recuperation; and, that while no doubt there is a permanently polluted zone reaching about half-way to the Lighthouse, the waters of the Lough seem to recover something approaching their natural condition at about that point, if we take the dissolved oxygen as an index.

Reduction in free and albumenoid ammonia.

This inference seems to get confirmatiom from tbe analyses in regard to free and albumenoid ammonia. The eight samples (series No. 6) taken on the line from Macedon Point to Holywood showed an average of ·02 free ammonia per 100,000, which indicates a reduction of 99 per cent. on the

two parts per 100,000 found in Belfast sewage; while the average albumenoid ammonia contained in the same samples was ·024 per 100,000; or, after deducting ·005, which is said by Professor Letts to be the normal amount in sea water, ·019 per 100,000. about 98·4 per cent. reduction on the amount (1·24 per 100,000) found in Belfast sewage.

In other words, it may be inferred from these data that, at a distance of abont two miles from the outfall, the Lough water has practically freed itself from dissolved impurities by dilution, oxidation, and other ways.

Bacteriological features of the dilution.

We have so far dealt only with the evidence of chemical analysis. It remains to note how far the bacteriological features of the sewage are altered after its dilution with Lough water. Although there are no bacteriological analyses of Belfast crude sewage to guide us, it may safely be taken that, like other sewages, it contains at the least 100,000 B. Coli per cubic centimetre; and without concerning ourselves about the total number of organisms that may be present in the Lough waters, many of which are natural to the sea water, it will suffice if we restrict ourselves to the evidence of the presence of B. Coli, these intestinal bacteria being characteristic of sewage contamination. In the bacteriological analyses which have been made of all the samples in the six series already referred to, the number of B. Coli present was determined. The relatively small number of B. Coli in the water samples as compared with the dredging samples is very remarkable. It is due probably to the fact that in settlement, the suspended matters of the sewage carry with them a large proportion of the bacteria, and that the sea water which has so largely diluted the sewage is inimical to the persistence of the Colon Bacillus; although it may also be partly explicable by the fact that the water samples were taken from near the surface.

Sample 1 in series No. 3 was taken near the mouth of the outfall shoot and contained 1,000 B. Coli per c.c. Samples 4, 5 and 9 in series No. 4, taken on the path of sewage discharge also contained 1,000 B. Coli per c.c., but with the exception of these, all the samples of the six series contained only from 1 in 100 c.c. to 100 per c.c.. and the average of the whole shows a reduction of 99·9 per cent. on the 100,000 per c.c. which we have assumed as originally present in the sewage.

Contamination of the banks on north shore.

On the other hand, the samples of dredgings show a large number of B. Coli in some cases: thus sample 2 A. of series No. 5 taken nearly a mile in front of the shoot showed actually 100,000 per c.c., and samples 1, 3a., and 4a., showed 10,000 per c.c., but others contained only from 1 to 100 per c.c., according to the situation from which they were taken. The samples of dredgings for the most part show evidence of serious contamination by sewage both in chemical and bacteriological analysis.

Danger of shell fish contamination.

The deposition of suspended sewage matter on the slob lands, carrying with it a large number of intestinal bacteria, obviously forms a very serious danger to the wholesomeness of the shell-fish, which are gathered on the exposed banks along the north shore within the City and for some miles beyond. The danger with cockles is all the more important because these are generally eaten raw in Belfast, and in many cases mussels also. Practically no oysters are gathered from the Lough.

Possibility of evils from permanently polluted zone.

We have now shown that there is evidence both chemical and bacteriological to indicate that the tidal waters of the Lough are practically free of impurities near the Lighthouse, 3½ miles from the outfall, but that there is a more or less polluted zone between these points, due to the daily discharge of sewage. How far is this permanent local pollution likely to give rise to direct danger or nuisance or to indirect evils? Sufficient has perhaps been said to show

that the deposit of the suspended solids of the sewage on the banks and northern shores of the Lough within and in the neighbourhood of the city, and its slow anaerobic putrefaction, give rise to direct nuisance from offensive smells.

On the other hand the de-aeration of the waters in the polluted zone, except within a small and constantly moving portion of it, is not so great as theoretically to render fish life impossible; and the aerobic processes of purification which are constantly going on in the waters do not give off offensive gases, and therefore cannot be said to bring about any direct nuisance.

Queen's Island sewage.

No reference has so far been made to the sewage from about 10,000 workmen at the Queen's Island Works, which is delivered at all times of the tide into the Abercorn Basin which is connected with the Victoria Channel of the Lagan. The suspended matter from this sewage no doubt mainly settles in the basin and in the channel, and must, therefore, add considerably to the expense of dredging. The dissolved impurities are carried with the rising tide up the river; but, considerably diluted as they are, they do not seem to have caused appreciable nuisance there. On the falling tide they are delivered into the channel beyond the Twin Islands, and may have contributed to the growth of Ulva in the Lough. We understand that it is proposed to connect this sewage with the Sydenham outfall.

Part II.

Recapitulation.

In the preceding Part I. we have shown that the suspended matter in the sewage amounting probably to about 400 tons of sludge or 40 tons of dry matter per day, has led to serious contamination of the slob lands and shores, and given rise to offensive smells at low water; and that it has gravely prejudiced the wholesomeness of the shell-fish which are still gathered from the banks. According to the Harbour Engineer's evidence it has also involved additional cost in dredging out the navigation channel.

The removal of the bulk of the suspended matter from the sewage before discharge is therefore an obvious necessity; but it seems that the dissolved impurities, largely diluted as they are, do not bring about any direct nuisance, and that notwithstanding the continuous discharge which has taken place for so many years, the waters of the Lough recover something like their natural purity well within the line of the Lighthouse about 3½ miles from the point of discharge.

Indirect evils

It is, however, alleged that not only does the ammonia given off as the result of the decomposition of the matter deposited from the sewage on the slob lands and shores encourage the development of certain seaweeds, but that the ammonia in the dissolved impurities is an even more important element in developing their growth.

It will be necessary now to investigate this part of the question.

Summer nuisance from the Lough.

During our visit to Belfast in the month of July, 1907, we were able to satisfy ourselves that serious nuisance arises from the Lough at low water, and that it is experienced in the city itself. At low water practically the whole bed of that part of the Lough which is within the city boundary is exposed, except the dredged navigation channel, which is available at all times for shipping, and the nuisance we observed appeared to be due to odours arising from the foul mud on this exposed bed and in the timber ponds, and also to odours arising from putrefying accumulations of green seaweeds which are cast up on the shores of the Lough near high water mark.

Weed growth on north shore.

On the north side, the foreshore was largely covered in July with these weeds from a point near the main drainage lands recently enclosed, as far as Macedon Point, nearly three miles away. The weeds were spread out so as to resemble a meadow, having a width of half a mile near the outfall works and becoming gradually reduced towards Macedon Point.

The weeds accumulate particularly in the corner formed by the recently reclaimed main drainage lands and the embankment of the Midland Railway which runs along the shore. We were informed by the City Surveyor, Mr. Cutler, that some 4,000 loads of decaying weed had quite recently been carted away from this spot by the Corporation.

Weed growth on south shore.

On the south side the foreshore was also very widely covered with the weeds from the mouth of the Connswater river at the city end for about three miles, to beyond Holywood, while from Cultra to about a mile from Grey Point, the width of the foreshore covered by the weeds was much less.

It would seem, according to the evidence, that there has always been a greater accumulation of weed on the south side than on the north side; and that the nuisance from the decaying weed has been more severely felt on the south side. It has led to the formation of a Joint Board comprising representatives of the Corporation, the Urban District Council of Holywood, and the Castlereagh Rural District Council, expressly for the purpose of removing the accumulations on that side; and at the time of our visit in July they were being steadily removed by means of barges, carts, and a tramway under the orders of this Board. We were informed that in the season 1906 some 17,000 tons had been so removed, and that considerable improvement in the local conditions had been brought about in consequence.

Nature of weed growth.

The weeds in question are, in the order of their abundance, *Ulva Latissima*, *Enteromorpha Intestinalis*, and *Enteromorpha Compressa*. All belong to the family *Ulvaceae* in the class *Chlorospermeæ* of Marine Algae. The last two weeds appear to be of little account, so far as the nuisance is concerned. The small surfaces of their fronds probably prevent them from being so easily detached from stones, shells, &c., as the *Ulva Latissima*, the fronds of which are very large and must offer greater resistance to moving water.

It would appear that these weeds are very widely distributed and very common on many coasts, that they are usually found together, and that they are essentially shallow water growths.

The *Ulva Latissima* continues to live detached, and often floats about in masses.* As a living weed, spread in thin layers over large areas exposed at low water, the *Ulva* is not only unobjectionable, but is probably beneficent, since it absorbs nitrogenous and carbonaceous matters from the sea water, and gives off when exposed to light very large quantities of oxygen. Indeed, it is this remarkable property of giving off oxygen, the gas collecting in minute bubbles in its fronds, which causes it to float.

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* "The *Algae* imbibe along their entire surface the materials needed for their support, and the roots are only employed for adhesion. The peculiar constituents of the soil are very important to the land plant; with the marine plant it is a matter of indifference whether the ground on which it grows is composed of granite, chalk, slate, or sandstone, if it only afford safe anchorage. Shores consisting of loose sand are barren."

"The *Chlorosperms* are found most frequently near high water marks, and love to lead an amphibious life, half in the air, half under water. To them belong the silky *Enteromorphae* and *Ulvae*, which on suitable spots cover the coast rocks with the most vivid green. Very remarkable, too, is the wide geographic extension of these genera. The *Ulva Latissima* and *Enteromorpha Compressa* of our coasts grow in the desolate shores of the Arctic Ocean, skirt the Tropical Ocean, and extend southward to Cape Horn."

("Marine Botany," Ward and Lock.)

"Seaweeds have no real root, and do not derive their nourishment from the soil as do the plants of earth. They adhere to the rocks or stones by simple discs, and draw their whole subsistence from the waters that surround and sustain them."

"These plants never have but one attachment during their whole lives, and if torn from that one object they never affix themselves to another."

"The most useful of the *Chlorosperms* may be found almost at the very margin of high water, where they live rather more in the open air than under water. These are the *Ulvae* and *Enteromorphae*."

("Common Objects of the Seashore," by Rev. J. G. Wood.)

Nature of the nuisance.

But when large quantities of this detached weed are driven by wind or tide, and left on the shore near high water mark in accumulations having a depth varying from a few inches to several feet, as often happens in Belfast Lough, the lower strata of the accumulations become black and putrid, give off sulphuretted hydrogen and other compounds, and very serious nuisance results.

Professor Letts' investigation.

Much of the information relating to this *Ulva* nuisance, especially in regard to the remarkable properties possessed by the plant of absorbing ammoniacal nitrogen, and to its association with sewage discharges, is due to the researches of Professor Letts. As result of work carried out for the Belfast Corporation, he has presented several valuable reports to that body on the subject. He also gave evidence before the Royal Commission on Sewage Disposal during their sittings at Belfast in 1902, at Local Government Board Inquiries held in 1904 and 1906, and before a Committee of the House of Commons in 1905.

Briefly, Professor Letts' conclusions are that *Ulva Latissima* depends chiefly for its excessive development in the Lough, on the nitrogen it can obtain from its sewage-polluted waters, and especially on nitrogen in the form of free or saline ammonia.

Professor Letts' proposals.

He advises, therefore, that in order to remove or reduce this before discharge, the sewage must be treated in the following manner :—

(1) Sedimentation.

(2) Percolating filtration of one half of the clarified sewage with production of nitrates.

(3) A process which he calls "denitrification," which will consist in mixing the filtered and nitrated effluent with an equal volume of unfiltered clarified sewage, and passing the mixture through contact beds which are also to be used for the treatment of storm waters. The final purification is expected to reach about 80 per cent. on the crude sewage.

In processes of biological filtration the result usually aimed at is the reduction of all impurities, with the incidental production of nitrates, which are of great value in securing the non-putrescibility of effluents; but at Belfast the object of filtration, if it is to be effective as regards *Ulva*, must be to remove the factors on which the *Ulva* thrives. Professor Letts has shown that nitrogen in the form of albumenoid ammonia is not taken up by the *Ulva*, but that it absorbs with avidity nitrogen from free or saline ammonia, and also, though at a slower rate, nitrogen from nitrates. The factors to be kept out of Belfast effluents are therefore free ammonia and nitrates.

It might be possible to balance the filtration so as to produce little or no nitrate, but this would be at the cost of leaving more free ammonia. Professor Letts concludes from his experiments that it will be cheaper and better to reduce the free and albumenoid ammonia even at the expense of nitrate production; and then to use the nitrated effluent for purifying another portion of clarified but unfiltered sewage.

In considering the effect of the dissolved impurities of the sewage in promoting the growth of *Ulva*, it may be useful to consider the conditions elsewhere.

It would appear that, although some *Ulva* nuisance has arisen in several coast towns in Great Britain, it is only at Belfast and to a less degree at Dublin, that it has attained sufficient importance to compel serious public attention.

The Thames.

For instance, notwithstanding the enormous daily discharge of 50 million gallons of London sewage into the Thames at Barking and Crossness, no *Ulva* nuisance seems to have arisen there. Here the suspended matters are first withdrawn from the sewage before its discharge

into the river. Also, the estuary from these places for 20 miles seawards is narrow and the currents are fairly strong, and it may be that these and perhaps other conditions, such as soft muddy bottom, may suffice to prevent the growth of *Ulva*. Nevertheless the fact remains that in spite of the enormous quantity of dissolved nitrogenous compounds discharged into the river, there is no appreciable development of the weed.

Cork.

Again at Cork, where the sewage of 80,000 people is discharged crude into the River Lee, we found *Ulva* growing only in very small quantities on the foreshore of the estuary, two miles below the city. The suspended matters of the sewage are deposited in the bed of the river, as evidenced by its evil smelling black mud at low water. It is possible that the current, which is about three knots, and other conditions, especially the large dilution that must take place before the dissolved impurities can reach the slob lands, may suffice to prevent the growth of *Ulva*, but the fact remains that in spite of the addition of the dissolved impurities contained in this sewage to the waters of the estuary, there is no serious growth of *Ulva*.

Dublin.

At Dublin Bay, where there is an *Ulva* nuisance, the conditions are worth consideration. On the occasion of our visit in August we found them as follows :—

The South Wall divides the Bay into two distinct parts, of which the northern part forms the Harbour, and receives the waters of the Liffey. The North or Bull Wall completes the enclosure of the Harbour, leaving only an outlet of about 1,000 ft. width. This enclosed Harbour is about three miles long by 1½ miles wide, but the navigation channel lies parallel and close to the South Wall. On the northern or Clontarf shore of this Harbour, a considerable area of foreshore is uncovered at low water, and at the time of our visit there was a considerable growth of *Ulva* there.

Less than a year ago the sewers of Dublin discharged at all hours into the Liffey, which was then very foul, the Liffey itself discharging as stated into the Harbour, mainly, of course, by way of the navigation channel Recently a main drainage system designed by Mr. Chatterton, M. Inst. C E., has been almost completed ; the sewage is conveyed to an outfall at the Pigeon House Fort on the South Wall, where the suspended matter is precipitated and barged to sea and the resulting sewage effluent is delivered into the navigation channel where the current is considerable.

The appearance of the *Ulva* growth on the Clontarf shore indicates that it has mainly been encouraged by the discharges from local sewers which still flow at all times of the tide over this foreshore. The growth spreads wide at the city end, and gets gradually reduced in width and abundance as the Bull Wall is approached, the reduction appearing to coincide roughly with the diminution of the population on this shore seawards ; while the growth appears to be most abundant in the immediate neighbourhood of the outlets of the sewers referred to.

It might be argued that this *Ulva* growth, as it exists now, is the remnant of that which had been encouraged by the polluted waters of the Liffey before the recent installation of the new main drainage outfall. But the distribution of this growth in the neighbourhood of sewers does not indicate that such is the case.

The contrast between the present condition of the Clontarf shore and that of the South shore is very striking. Standing on the South Wall, the Clontarf shore is seen to be more or less green with weeds, while the South shore shows a perfectly clean strand. It appears that practically no sewers now discharge on this South shore. The Rathmines and Pembroke sewage is conveyed to an outfall on the South Wall nearer the sea than the new Dublin outfall, where it is discharged crude into the navigation channel on the ebb tide ; while the sewage of the remaining population on the South shore has, by a joint scheme, been intercepted and carried to an outfall into deep water at Kingstown West Pier. Before these works were carried out,

many sewers, we are informed, discharged on this South shore, and there was then a considerable growth of *Ulva* in the neighbourhood of their outlets.

Belfast.

Moreover, the history of the *Ulva* nuisance at Belfast itself is by no means clear on this question of the relative importance of the dissolved impurities.

Before 1893, when the main drainage outfall came into operation, the Belfast sewers discharged into the Lagan, and most of the suspended matter, no doubt, settled in its bed. The sewage, thus deprived of its suspended matter and also much diluted, ultimately reached the Lough between the Twin Islands at the mouth of the Victoria Channel, and thence passed towards the sea keeping largely, no doubt, to the track of the navigation channel, on the south side of the Lough. These conditions much resembled those prevailing now at Cork, and those that prevailed till recently at Dublin, except that the currents of Belfast Lough are more sluggish. The volume of sewage was then considerably less than it is now.

Since 1893 the sewage has been taken out of the Lagan, with great advantage to the condition of the river itself, and the growing volume of the flow has been concentrated in an outfall discharging, not into the navigation channel, where the speed of the current is at least greater than anywhere else, but into the Lough itself nearer the north shore. Moreover, though this outfall discharged at first below low water beyond the West Bank, it soon came largely to discharge, as we have shown, over the shoh lands of this bank where the currents are only one-fourth to one-third knot per hour, with the result that the bulk of the suspended matter has settled there and in the neighbourhood of the northern foreshore of the Lough.

Ulva nuisance greater since 1893.

There seems to be no doubt that, although there was an *Ulva* nuisance on the shores of the Lough before 1893, the nuisance has become much greater since that date. The position of the main outfall would readily explain an increased growth of *Ulva* on the north shore, if such has in fact taken place, because as we have shown (on page 54) the suspended matter in the sewage has, on account of the sluggish currents near the outfall, mainly settled on the shoh lands to the north of the navigation channel. But it is a question whether the main outfall can have had any important effect in promoting the growth of *Ulva* on the south shore, not only because it is unlikely that the suspended matters would be carried to any important extent across the navigation channel to the south shore, but because the dissolved impurities when discharged under normal conditions in the first half of the ebb, could only return to either shore, especially that of the South, in a very dilute condition. Even when discharge has taken place on the rising tide, the position of the outfall to the north of the navigation channel, makes it more likely that the tide would carry the sewage to the northern backwater and shores than to the southern.

On the other hand the nuisance has undoubtedly been more felt on the south, and it may have been influenced by prevailing winds drifting detached weed from the northern banks to the south.

In this connection, it is unfortunate that in the valuable analyses of samples of Lough waters carried out by Professor Letts, the results of which are brought together graphically on Plate 7 of his report of 1907, very few were taken on the south of the navigation channel, but the few there shown indicate relatively little impurity, and so far as they go, bear out our general conclusions.

The important work carried out by Professor Letts for the Corporation furnishes us with the only information available as to the condition of the waters of the Lough, and might with advantage be extended.

The analyses of thirty-nine samples are given on Plate 7 just referred to, and it is interesting to note how largely the dissolved impurities have been reduced by dilution.

Thus of thirty-nine samples taken within three miles of the outfall, and on either side of it, twenty six contained only ·05 to ·005 parts per 100,000 of

free ammonia, which, as compared with that factor in the crude sewage samples (2 parts per 100,000) indicate a reduction of impurity by dilution of 97 to 99½ per cent. The worst of the samples taken within a mile of the shoot on the path of the discharge only contained from ·13 to ·05 per 100,000 of free ammonia.

Effect of dissolved impurities.

On the whole, therefore, and keeping in view what we found at Cork and at Dublin, we are inclined to say that the available evidence does not prove the contention that the dissolved impurities from the main outfall have had a predominant, or even a very important effect, on the growth of *Ulva* in the Lough; but rather that the increase of the weed, which has followed the change of sewage outfall since 1893, has been more closely associated with the addition of the suspended matters of the sewage to the northern waters of the Lough, to the frequent discharge of sewage which has taken place within prohibited hours on account of inadequate storage, and to local discharges on the foreshores.

Local discharges.

The effect that local discharges of sewage may have upon the growth of *Ulva* must not be lost sight of. On the south shore there are many such discharges of sewage; a considerable volume of sewage now falls into the south backwater, into which also the dirty Connswater river discharges; distillery refuse finds its way thither either directly or by storm overflows; and all these are delivered on the shallow banks in front of the mouth of the Connswater, banks specially suited to the growth of *Ulva*, and which the late Mr. Giles, according to his evidence given at Belfast in 1904, believed to be the nursery of the *Ulva* growth. There is also on that shore the sewage of Holywood, with a population of nearly 4,000, and of other smaller communities, which for the most part is delivered at all times of the tide directly over the south foreshore. Similarly there are still important sewage discharges on the north shore.

We fully agree with Professor Letts, where he says in his report of 1907, "There can be no doubt that when crude sewage is poured into a foreshore where the green seaweeds are already growing, it encourages their growth to a much greater extent than if the same volume of sewage were discharged into deep water, and only reached the seaweeds in a dilute condition."

Part III.

Intercepting sewers.

The Corporation of Belfast are now engaged in the construction of an intercepting sewer to take up the sewage hitherto discharged locally along the north shore from the city boundary at Greencastle, and to bring it to the main outfall. And with regard to the south side of the Lough, the Corporation propose to carry out a scheme which is intended to bring to an outfall at Sydenham a portion of the sewage which now passes to the main outfall, along with the separate discharges of sewage on that side, and to subject the joint flow of about 4 million gallons a day to treatment at works to be constructed there. But on this side there will still remain the sewage of the population beyond the city boundary at Tillysburn, and also Holywood, and the dirty flow of the Connswater; while on the north shore there are similar discharges beyond the boundary of the city.

It will be seen, therefore, that the Corporation are taking steps to concentrate the discharge of the sewage of the city at two outfalls—one on the north and one on the south side of the Lough. Nothing, however, has yet been definitely settled as to the method of treatment to be adopted.

Withdrawal of suspended matter essential.

Clearly, in the first instance, the bulk of the suspended matter must be removed, not only from the dry weather flow, but also from the storm waters, say to six volumes; for these waters bring down, at times, very large quantities of foul matter, mostly in suspension. In the situation of Belfast, sludge can economically be barged to sea.

Chemical precipitation requires a relatively smaller area of tanks, but against the reduced cost of tankage must be set the cost of the chemicals and that of barging a larger volume of sludge to sea. With an adequate capacity of tanks, however, chemicals will not be required.

Capacity of tankage.

The Corporation already have available the old storage tank of 5 million gallons capacity, which the City Surveyor is now dividing into three settling tanks, and we understand that additional tankage is to be provided. A tank capacity equal to half the average daily dry weather flow at each outfall, would permit of storm waters to the extent of six volumes receiving a minimum settlement of two hours, and give ample settlement for the dry weather flow after allowing one-sixth of the tankage to be out of operation for cleansing. Unless chemical precipitation be resorted to, this capacity of tankage should in our opinion be provided, and provision be made for future extension.

Limitation of discharge to ebb tide.

The question now arises whether further treatment of the sewage is in the condition of Belfast necessary, and whether it would not suffice to discharge the settled sewage into the Lough, strictly limiting the discharge to the first $3\frac{1}{2}$ hours of the ebb.

During the ebb tide the course of the tidal waters must mainly be *from* the shores towards the navigation channel and the sea. If therefore the discharge can be limited as suggested, the dissolved impurities could not reach the *Ulva* banks until the return of the tide, or, in other words, until large dilution has reduced to a negligible quantity the factors that promote the *Ulva* growth.

Necessity for storage.

This plan, however, involves the provision of storage, for if the discharge is limited to the first $3\frac{1}{2}$ hours of the ebb, the clarified sewage must be held up for $8\frac{1}{2}$ hours per tide. It would be necessary, therefore, to provide at this outfall adequate storage in respect of at least the dry weather flow. This much is essential, but it would be desirable also to store part or all the storm waters dealt with, if this should be found practicable within reasonable expense, for, as already stated, storm waters bring down at times, especially after dry weather, a large amount of impurity, but this is mainly in the form of suspended matters. When these have been settled out, the dissolved impurities are already to some extent dilute, and the limitation of their discharge to the first half of ebb, though in itself desirable, is not essential. The discharge of storm waters is only occasional, and the important matter is to limit the discharge of the dry weather flow which is continuous.

There is, adjoining the existing outfall works, an area available for the provision of storage, on land owned by the Corporation, who have recently completed the enclosure of eighty acres of slob lands for the purpose of providing a site for filter beds; an important work to which it is fair to call attention. We do not foresee that the provision of storage would involve difficulty or serious expense; and indeed it would seem that some storage is proposed in connection with the filtration scheme, for Professor Letts in his report thereon of 1907 points out that after percolation and denitrification, the effluent is to be discharged into ponds or lagoons and thence into the Lough.

Storm water treatment.

In regard to storm waters, the plan which is being prepared by Mr. Cutler, the City Surveyor, provides, as we understand, that dilution up to three times the dry weather flow, is to be treated by the complete processes, and that three more volumes are to be treated on storm beds. Effective sedimentation of storm waters seems to us preferable to mere treatment over storm beds as usually carried out. It would appear that it is contemplated to treat in all six volumes of the dry weather flow. The capacity of the main sewers is sufficient to deliver that volume to the works, but the pumping plant at No. 2 station is now only sufficient to lift two volumes of the dry weather flow. (See section on Main Drainage p. 49).

Sedimentation and limitation of discharge probably sufficient.

In our opinion a scheme of sedimentation, combined with storage and strict limitation of discharge to the first $3\frac{1}{2}$ hours of the ebb, would probably be effective and sufficient; and its preliminary provision would not prejudice the carrying out of a filtration scheme should it be found ultimately necessary, because the sedimentation of the sewage to the extent of six volumes is in any case contemplated.

The filtration scheme.

As to the scheme of filtration proposed by Professor Letts, we agree with him in preferring percolating filtration to contact beds for his second process, and we may say generally that, apart from cost, we think the scheme practicable. If, however, the purification to be obtained by sedimentation, filtration, and denitrification cannot practically be brought beyond the 80 to 82 per cent. indicated by the experiments, it would be advisable, according to Professor Letts' estimate of the importance of the dissolved impurities, to limit the discharge of at least the dry weather flow to the first half of the ebb, and therefore to provide some storage. If an effluent containing 20 per cent. of the original impurities is to be discharged at all times of the tide, it would, with a rising tide, carry an appreciable amount of dissolved impurities over the *Ulva* banks, which on the north shore are near the outfall.

No estimates of cost available.

No definite plans for the complete scheme of filtration recommended by Professor Letts were put before us, nor has such a scheme, with estimates of cost, been laid before the Corporation; but Mr. Cutler, the City Surveyor, stated in evidence that the plans were being prepared in his office, and that he expected shortly to lay them before the Council for their consideration. We cannot, therefore, express any more definite opinion upon them than we have already done, but we should add that if it is proposed to deal by complete treatment with sewage up to three volumes of the dry weather flow, and by partial treatment with three more volumes, the work will necessarily be very costly.

Urgency of sedimentation.

It is right that we should refer to the fact that the time within which the Corporation undertook, in 1898, to complete their purification works to the satisfaction of the Local Government Board, expired in 1902; and it is very much to be regretted that sedimentation prior to discharge has not been effected long ago. It is a necessary part of any process to be adopted, and we are strongly of opinion that this part of the work should be completed without delay. On the other hand, in view of the special character of the Belfast problem in relation to the *Ulva* growth, the Corporation seem to us to have been warranted in deferring the execution of costly works for filtration, until the valuable investigations which Professor Letts was carrying on on their behalf should have been completed.

Will filtration safeguard shellfish?

The circumstances of Belfast are quite special, as we have shown. In ordinary circumstances it can hardly be doubted that mere sedimentation or precipitation of the suspended matters would suffice without further treatment of the sewage. But at Belfast the matter has to be considered from the point of view of shellfish, and of *Ulva latissima*. We have shown, in another part of our report, that no treatment of sewage will suffice to safeguard these former completely, and that the only effectual remedy, so far as they are concerned, is to prohibit the gathering of those shellfish for human consumption.

Will filtration remove the *Ulva* nuisance?

There remains for consideration whether even a complete and costly treatment of the city sewage by filtration will entirely remove the *Ulva* nuisance.

If, as the result of a complete scheme of filtration, the purification attained does not exceed the 80 per cent. anticipated, there will remain 20 per cent. of the factors which promote the growth of the *Ulva*, and it must be borne in mind that even if dilutions to six volumes should ultimately be treated, there will still remain a considerable untreated discharge of sewage through storm overflows. Again, a large amount of impurity is discharged into the Lough by the small streams which pass through the city, and the evidence brought before us showed that the Pound Burn, the Blackstaff, and the Connswater were very foul. We were unable to ascertain to what extent sewage is still discharged into these streams, but the City Surveyor stated that sewage had been and was still being diverted from the streams to the sewers. It is very necessary that this work should be continued, and every effort made to divert sewage and trade effluents from the streams, but even then the streams will still carry down impurities from various sources, which, though each contribution may be small, will represent as a whole a considerable volume of impurity which must be taken into account.

Then again there are many local discharges of sewage into the Lough from the population outside the city. Finally, as Professor Letts has pointed out, the suspended matter which for many years has been settled on the mud banks will, for possibly a long period, continue to give off ammonia and so feed the *Ulva*; and whatever works of sewage treatment are settled upon, considerable time will necessarily be required to carry them out.

It will, therefore, be necessary for some years at least, that the Corporation of Belfast within its boundaries, and the Joint Board on the south shores of the Lough should continue to remove accumulations of weed, and this should be done in a more systematic and efficient way than at present, for after removal from the shores, it is now often left in rotting heaps in fields near the shore. It should be possible by good organisation to bring about a better and more rapid distribution of the weed as manure upon the farm lands.

Utilization of the *Ulva*.

We suggest that experiments should be made as to the best methods of dealing with the *Ulva* accumulations. It might be possible to press the weed, so as greatly to reduce the bulk to be transported. It might be financially possible to go further and dry the pressed weed and grind it up, so as to check any nuisance that might arise in storing it, and produce manure in a form readily applicable to land. In such form it should command a ready sale even at a distance from the Lough, in view of the large amount of nitrogenous matter which Professor Letts has shown it to contain.

Professor Letts has suggested that the *Ulva* might be used for the production of sulphate of ammonia, one ton of this salt being obtainable from 14 tons of dried weed; and again the gathered *Ulva* might be barged to sea.

It is not unlikely that experiment may lead to some method of dealing with *Ulva* accumulation, which may not perhaps cover the cost of removal but may go a long way in reducing it.

Possible acceptance of the *Ulva* as a useful agency.

If the question involved only affected Belfast, it would be worth while for the Corporation of Belfast to consider if it would not be cheaper for them to deal with the *Ulva* accumulations in some of the ways suggested, instead of carrying the purification of their sewage sufficiently far to remove all the matters on which the *Ulva* thrives; in other words, to accept the weed as a useful agency for purifying the Lough waters and supplying them with dissolved oxygen; and to spend money in removing and utilising the accumulations. As the case stands the possibility of such a solution of the difficulty by means of a Joint Board representing the authorities of all districts from which sewage passes into the Lough is well worthy of consideration.

Reclamation of slob lands.

We are of opinion that the slob lands on the south of the Lagan within the area of the city should be reclaimed, as was done in the case of the adjoining area which now forms the Victoria Park. These slob lands within the city in front of the mouth of the Connswater River are covered with *Ulva*. Professor Letts has several times called attention to the necessity of reclaiming them, and pointed out that if there were no slob lands there would be no *Ulva* nuisance. We have no doubt that by thus reducing the area of the *Ulva* banks, the *Ulva* accumulations on the south shore would be considerably reduced. Professor Letts states at the conclusion of his report of 1907, that not only has the removal by the Joint Board from the south shore of the accumulations there, been of "immense service" in reducing the nuisance, but that this removal has served another important purpose in withdrawing from the Lough the nitrogenous constituents of the seaweed removed, which would otherwise have served to feed another generation of the weed.

Value of removal of *Ulva* accumulations from shores.

Use of Copper Salts for checking the *Ulva* growth.

It seems also to be a matter for consideration whether it would not be practicable, as a temporary measure, to try the effect of copper salts as a means of control on the *Ulva* growth. The effect of such salts, even when enormously diluted, on the growth of algae in water reservoirs, has been so encouraging, that its effect in the case of these marine algae is well worth a trial. Professor Letts agreed that, if financially practicable, such a measure would be effectual. There would seem to be more than one method by which such a measure might be given a trial.

Section VII.

SANITARY CIRCUMSTANCES AND ADMINISTRATION.

Belfast a modern town.

In reviewing the Sanitary Circumstances and Administration of Belfast it is desirable to recall the essentially recent date at which its industrial development may be said to have begun.

From this point of view its position is unique among the cities of Ireland.

Its growth belongs wholly to the latter half of the 19th century, and was therefore contemporaneous with the awakening of sanitary effort in towns elsewhere.

In 1851 its houses numbered only 12,342, and its population 87,062, while in 1901 the former had increased to 67,108 and the latter to 349,180. The relatively greater increase in the number of houses than in population has something in common with other industrial towns, but lack of information for the earlier period precludes comparison of the actual size of the average house in both. The decrease, however, in the average number of occupants per house (from 7 to 5) suggests, what observation and the evidence confirm, that pressure on house accommodation in Belfast does not exist to any appreciable extent.

Matheson, 17, 64, 66, 67.

The present area of Belfast, exclusive of tidal waters, extends to 14,716 acres, and the population resident thereon or its "density" at the 1901 census was 23 persons per acre, compared with 27 in Dublin, and 34 in Cork.

Cutler, 2539.

Its position made expansion easy, and its recent growth gave the opportunity for providing streets of reasonable width. Moreover, its advisers were, as we shall see, early alive to the need for regulating this growth by well-intentioned legislation.

No inherited problems.

It is singularly free from those inherited structural problems, which in other cities have so often made difficult the path of sanitary reform.

The increasing tide of immigrants which its industrial development attracted would appear to have been accommodated in houses built to meet the demand.

There were no doubt many defects in their structure and internal arrangements, and a faulty appreciation of the importance of cubic space within, and of free space around them, but they had the unmistakable advantage of being built to meet the requirements of one family only. There are very few instances, throughout the whole city, of old houses sub-divided for letting in tenements which form so striking a feature in Dublin and other cities. But while Belfast may be said to have inherited no sanitary problems, it had to cope with a natural one in respect of its situation on a relatively flat plain at a low elevation, which made drainage difficult.

Scope of Local and General Acts affecting Public Health.

Munce, 11006–7.

It was suggested in evidence that many of the earlier well-intentioned provisions of the local Acts, obtained by the Belfast Corporation, were rendered nugatory through the operation of two factors having different origins. It was stated that the earlier Acts themselves provided no penalties for their infringement, and that until 1890 the staff provided by the Corporation was inadequate for the purpose of supervising the enforcement of many of their clauses.

Powers not enforced

While the former statement is supported by the fact that the omission to provide a specific penalty for failing to comply with many of the provisions of the Acts of 1845, 1850, 1865, and 1868, was remedied in the Act of 1873, Section 4 (1), there was no evidence that any effort had been made by the

Corporation to avail themselves of a drastic indirect penalty conferred by Section 140 of the Act of 1845. This empowered them to take down, rebuild, or alter, at the expense of the owner, any house or dwelling, erected subsequent to the passing of that Act and which contravened its provisions. Moreover, section 98 of the Act of 1865 imposed a substantial money penalty, supplementary to the above provisions, while section 25 of the Act of 1868 imposed a penalty for contravention of section 75 of the Act of 1865, which prohibited occupancy of any house until the road leading thereto had been properly made and sewered. The contention that there was no method of enforcing observance of the provisions of the Act of 1845 is therefore not substantiated.

Codification necessary.

In considering the various provisions in the local and general Acts, together with the regulations and byelaws which form the sanitary code of Belfast, a difficulty arises from the multiplicity of the Acts in which these provisions are contained, a difficulty, however, which is not peculiar to that city. The Belfast Corporation have obtained fourteen or fifteen local Acts dealing with Public Health administration at one point or another, and, in addition, all the Public Health and allied Acts, which are of general application, are also operative. From this not only confusion but inefficiency in administration, is bound to arise, and much energy must be wasted in unravelling provisions which a simple codification would prevent.

A few general observations may here be made on such provisions as have a bearing on the subject of our Inquiry.

In many respects the provisions of the local Acts are satisfactory, but in some important instances they may be waived with consent of the Corporation. We consider this a grave defect. It places the officers of particular departments in doubt as to their action, and exposes members of the Corporation to pressure from outside influences.

Irregular application of provisions.

Moreover, it was stated by several witnesses that the Corporation, or the Committee representing them in particular instances, were unusually susceptible to appeals by owners of buildings which fell short of the statutory requirements. Indeed it would appear that plans which failed to gain the approval of the surveyor's department, because of non-compliance with the requirements of the local Acts and byelaws, were sometimes approved by the Corporation, and that requirements of the officers of the Public Health department were liable to be waived by their own Committee. This cannot have been without effect in lessening the interest and energy of the officers of the department on which the exercise of these provisions fell. The value of statutory provisions and byelaws depends on the energy and impartiality with which they are applied.

Cutler, 2548, 2551.
O'Neill, 14986–15001.
Ward, 11611.

Insufficiency of provisions

In other respects the provisions are insufficient. Illustration may be taken from the sections dealing with the provision of open spaces or yards behind houses.

The local Acts do not provide in a satisfactory way for this. Section 124 of the Act of 1845 enacts that to each dwelling-house the owner shall provide and attach a yard of not less than ten feet in depth from the rear wall of the house, but this provision is uncertain as to the other dimensions of the yard, no width or area being stated. It appeared at the Inquiry that the Corporation, after taking counsel's opinion on this section, decided that an area of 100 square feet should be required. It is to be regretted that up to the present time a more satisfactory provision regarding open spaces behind dwelling-houses has not been secured, and it is not surprising that, as a consequence, many houses in Belfast have yards attached to them which are inadequate.

Building Bye-laws.

In 1890 bye-laws as to new buildings, &c., were made by the Corporation under the Belfast Improvement Act, 1878, and the Public Health (Ireland) Act, 1878, but these bye-laws provide a very limited and by no means

satisfactory building code, even when considered as supplementary to the provisions of the local Acts, although many of these are so specific as to give them the character of building regulations.

The bye laws do not, for instance, supplement the inadequate provisions in the local Acts as to yards or open spaces behind houses, and they permit the erection of an ashpit at a distance of two feet, and of a privy at a distance of four feet from a dwelling-house. Improved bye-laws with respect to buildings are much required, and we were glad to be informed that a new code is now under consideration.

Committees.

For the purpose of administering the local and general Acts, which together constitute the sanitary code of Belfast, the Corporation appoint certain Committees which are arranged into three groups. (Standing Order 47).

Group I. consists of the Gas Committee, Improvement Committee, Public Health Committee, Tramways and Electricity Committee.

Group II. of the Finance Committee, Library and Technical Instruction Committee, Police Committee, and Works Committee; and,

Group III. of the Baths and Lodging House Committee, Cemeteries and Parks Committee, Law Committee and Market Committee.

Several of these Committees have duties which are related to Public Health administration, and their scope may be here indicated :—

Group I.—This includes ;—

(*a.*) The Improvement Committee, and

(*b.*) The Public Health Committee.

(*a.*) *Improvement Committee.* (Standing Order 61). Among other duties this Committee has charge of the

"Surveyor's Department, including the approval or disapproval of all plans and specifications submitted of streets; also of all plans and specifications prepared by the Surveyor for Public Works, &c."

(*b.*) *Public Health Committee.*

"The Public Health Committee shall have authority to carry out and enforce within the County Borough all provisions whether of a Public or Local Act of Parliament, or any Bye-Laws in force within the Borough in relation to nuisances and sanitary matters. To carry into effect the provisions with respect to Infectious Diseases and Hospitals, and the isolation of cases of Infections Disease. To carry out and enforce the provisions of the Sale of Food and Drugs Act, 1875, and the Acts amending and extending the same; the Diseases of Animals Act, 1894: the Factory and Workshop Acts, 1878 to 1891; the Shop Hours Act, 1892; the Housing of the Working Classes Acts, 1885 and 1890; the Merchant Shipping Act, 1883, Section 48; and the Local Government Board (Ireland) Provisional Orders Confirmation (No. 4) Act, 1890, so far as relates to the Port of Belfast. The said Committee shall also have charge of the House Cleansing Department, and be responsible for the carrying into effect of all Bye-Laws relating to the Public Health Department."

Group II.—Of this Group it is only necessary to specify the scope of the Works Committee (Standing Order 68) :—

"The Works Committee shall have charge of the general direction of all outlay on the streets, roads, footpaths, bridges, and sewers of the city, and the general direction and control of the Street Inspectors and employes of the Scavenging Department; also the execution of all Works required to be done under the Superintendent of Works or otherwise than by Contract; and to have charge of the carpenters' and smiths' shops, and the purchase of all materials for same."

Group III.—Three of the four Committees comprising this Group have certain public health functions, but note may be taken of the circumstance that the Market Committee controls the officials responsible for the inspection of animals slaughtered for food.

As Standing Order 47 provides that no member of Council shall serve on more than one Committee of each group, it follows that members of the

Public Health Committee cannot also serve on the Improvement Committee, although that Committee superintends the Surveyor's department, before which come all plans for buildings.

The circumstances attending the growth and development of the functions of municipal administration in different cities have been so diverse that uniformity in the methods by which these functions are discharged is scarcely to be expected; indeed in view of variation in local conditions it may not even be always desirable. Members of the Corporation who wish to devote themselves to sanitary matters should not be debarred from serving on the several committees more especially connected with Public Health; and as far as possible the Public Health Committee should control all the departments which are most closely connected with Public Health. The present practice of placing the sewers of the city under a different committee from that which is responsible for their structural upkeep and efficient working, seems to have little to commend it, while the separation of house-cleansing (removal of ashpit refuse, &c., Group I. (*a*)) from street-cleansing (scavenging, Group II. Works Committee) tends directly, in our opinion, towards inefficiency in both.

Organisation of Public Health Department.

For all purposes, save that of "house-cleansing," by which in Belfast is meant domestic scavenging or the removal of ashpit refuse, the staff of the Public Health department, in addition to the 14 Medical Officers of Health, numbers in all 48. It is composed as follows:—

1 Medical Superintendent Officer of Health,
1 Executive Sanitary Officer,
2 Chief Sanitary Sub-Officers,
14 District Sanitary Sub-Officers,
5 Female Inspectors (Infectious Diseases),
2 Inspectors under Food and Drugs Act,
2 „ of Dairies and Cowsheds,
3 „ for the purposes of the Factory and Workshops Act,
1 Inspector for Common Lodging-houses,
1 Port Sanitary Officer,
2 Drain-testers,
3 Disinfectors,
4 Temporary Officers,
1 Notice and Summons Server,
1 Porter and Messenger,
5 Clerks.

Medical Officers of Health.

The system of Public Health administration in Belfast is similar to that which exists in Ireland generally. The basis of this system is that every Dispensary Medical Officer appointed by the Poor Law Guardians to attend to the sick poor under the Medical Charities Act, is *ipso facto* Medical Officer of Health also of his dispensary district. He is, furthermore, almost invariably Registrar of births, deaths, and marriages of the same district, and also Public Vaccinator.

In the principal cities and towns of Ireland there is usually, in addition to the Medical Officers of Health, as above noted, a Medical Superintendent Officer of Health. This officer is appointed expressly as such by the Sanitary Authority, and he is not, of necessity, connected with the Poor Law medical service, as the district Medical Officers of Health are.

The appointments of all Dispensary Medical Officers are made subject to the sanction of the Local Government Board for Ireland, and when sanctioned the moiety of the salaries allotted to them as Medical Officers of Health is recouped from public funds.

Similarly, the appointment of a Medical Superintendent Officer of Health is subject to the sanction of the central department, and in the case of County

Boroughs he must have a diploma in Sanitary Science, Public Health, or State Medicine. The sanction of the central department involves recoupment from public funds of half the salary, even in County Boroughs.*

All the appointments we have been considering, once they have been made and sanctioned, are in the nature of permanent appointments, and are not compulsorily terminable except by, or with the sanction of, the Local Government Board.

In the case of Belfast there are 14 Dispensary Medical Officers (and consequently 14 Medical Officers of Health) who have been appointed by the Belfast Poor Law Guardians. There is also the Medical Superintendent Officer of Health appointed by the Corporation. This office is held at the present time by Dr. Hugh William Bailie, L.R.C.P., L.R.C.S. Edin., L.F.P.S. Glasgow, 1888. He holds the Diploma of Public Health (1905) of the Royal College of Physicians and Surgeons of Ireland. He was appointed in November, 1906, and is required to give whole time service at a salary of £600 per annum.

The duties of each of the 14 Medical Officers of Health of Belfast and of the Medical Superintendent Officer of Health are laid down in an Order of the Local Government Board (Sanitary Order, No. 4). Each of the former is required, amongst other things, to inquire into and ascertain the causes, origin, and distribution of disease within his district, and, by inspection of his district both systematically at certain periods and at intervals as occasion may require, to keep himself informed of the conditions injurious to health therein, and regularly report the same to the Corporation. Similarly, the Medical Superintendent Officer of Health is required to perform the like duties for the County Borough as a whole, and also to direct and superintend the work of the Medical Officers of Health.

There is theoretically much to be said in favour of a system such as the foregoing, which aims at bringing into relation and co-operation with the principal medical adviser of the Corporation a number of medical men in daily association with the poorest of the population, especially as these medical men are also Registrars of deaths.

It might be expected that under such a system much valuable information could be collected by the Medical Officers of Health regarding influences affecting the health of their districts, regarding the sickness prevailing at one

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* The system in England and Wales differs considerably from the above. Every sanitary authority is required to appoint a "fit and proper person" expressly as Medical Officer of Health, but a District Medical Officer, the person who corresponds to the Dispensary Medical Officer in Ireland, can only serve as the Medical Officer of Health with the permission of the Local Government Board.

Apart from this, the sanction of the Board to the appointment of a Medical Officer of Health is not specifically required, unless the local authority desire, as they commonly do, to secure the re-payment of a moiety of the salary, which in England is now payable from the County Fund and not from the Exchequer. All appointments of Medical Officers of Health are now required however to be made subject to the Order of the Board which prescribes their duties and so forth.

In the case of appointments which the Board are asked to sanction, the Board have power, which they have not infrequently exercised, to take into consideration questions other than salary before coming to a decision: but if this decision is adverse, the local authority are at liberty to persist in their own appointment, without re-payment of salary, provided that a District Medical Officer has not been selected by them.

A further difference is that in England and Wales it is the exception for Medical Officers of Health to be appointed permanently, so that they do not possess security of tenure such as they appear to possess in Ireland. In the case of districts in England and Wales with a population of 50,000 or more the Medical Officers of Health must hold a diploma in Sanitary Science, Public Health, or State Medicine.

In Scotland these appointments are regulated by the Local Government (Scotland) Act, 1889, section 54, and the Public Health (Scotland) Act, 1897.

The former (sub-section 2) provides that no person shall, after the first day of January, 1893, be appointed the Medical Officer, under the Public Health Act, for a county or district or parish which contained according to the last published census, a population of 30,000 or upwards, unless he is . . . . on the Medical Register as the holder of a diploma in Sanitary Science, Public Health, or State Medicine under Section 21 of the Medical Act, 1886, while the Public Health (Scotland) Act, 1897, provides that no person shall be appointed as the Medical Officer of any borough, or of any district other than a borough, unless he possesses the qualifications set forth in the above quoted section of the Local Government (Scotland) Act, 1889.

time and another among the poor attended by them, and also regarding the all-important returns of mortality in their possession. On the other hand, it might be expected that the Medical Superintendent Officer of Health could collate this information, and guide the district Medical Officers along useful lines of investigation, such as might become evident to one in a position to survey the needs of the city as a whole.

No doubt the aim of the system was something of this sort, but in practice it does not work satisfactorily. In the first place, for reasons which are detailed elsewhere in our Report, no information is given by the Medical Officers of Health regarding their mortality returns, with result that, as already shown, the Medical Superintendent Officer of Health is in complete ignorance of all the useful details of the vital statistics of the city. Moreover, it does not appear, so far as may be judged from the evidence of those who appeared before us, that the Medical Officers of Health themselves make any attempt to learn from their death registers, even for their own information, anything of the most elementary details of the vital statistics of their respective districts. Thus, one of the Medical Officers of Health informed us, that in his opinion, the death-rate of his district was low, but it transpired that he did not know, and, indeed had not calculated, what the death-rate was.

Secondly, no information is given by the Medical Officers of Health regarding sickness in their districts, beyond that which is required of all medical practitioners under the Infectious Disease (Notification) Act, 1889. Under a special arrangement which has recently been made, they were called upon, in return for slightly increased remuneration, to notify to the Corporation all cases of phthisis under their charge, but as regards such diseases as bronchitis, pneumonia, tubercular diseases (other than phthisis), diarrhœa, heart disease, infectious diseases other than those which are notifiable, ailments of infants and children, and so forth, knowledge of which may be useful to a public health authority, no information is given by the Medical Officers of Health.

Lastly, in connection with their duty to systematically inspect their districts and to ascertain the conditions injuriously affecting health therein, it seemed to us that, in practice, the Medical Officers of Health in Belfast limit themselves merely to reporting such "nuisances" as may come under their observation in the course of their daily work among the poor. This work is no doubt useful, but it scarcely requires, in itself, the services of a medical man, and falls rather within the scope of the sanitary sub-officer.

The system therefore, in practice, falls very far short in Belfast of what, no doubt, was intended. The reasons are not far to seek, and to some extent seem to be inherent in the system itself. Most of the Medical Officers of Health in Belfast are in charge, as Dispensary Medical Officers, of very populous districts, and besides their official work among the sick poor, which is commonly a heavy daily task in itself, most of them are engaged in private practice. So that it is of necessity almost impossible for them to attend to more than relatively trivial matters of public health concern in their districts, or to do anything by way of investigating either the general "conditions affecting the districts injuriously," or their valuable death returns. And, in any event, their duty to the sick must remain their first obligation.

In addition to these defects of working, the question of remuneration is one of essential importance. In Belfast the Medical Officer of Health receives as Dispensary Medical Officer an average of about £110 per annum, as registrar about £150 to £200, and as Medical Officer of Health, £20 to £25. It is but natural that an official should allot his time for the performance of his various duties somewhat in accordance with the relative remunerations attaching to them. Obviously his duties as a Medical Officer of Health cannot appear to him of great importance from this point of view.

It seems to us, therefore, that if this system is to be maintained, its conditions must be modified so that there may be reasonable expectation of its working, in practice, in the way it was intended to work. This would appear

to involve an increase in the number of these officers, because it is plainly useless to look for important public health work from an official hard put to it to find time for such work, whether his remuneration be increased or not.

The only alternative seems to be to abandon the system as unsuitable and unworkable in the case at least of a large city like Belfast, and to utilise the funds expended on it to more useful purpose.

We are of opinion that this alternative course should be adopted, and that re-organisation should be effected so as to bring the Public Health administration into line with that which obtains in the great cities of England and Wales, and Scotland, by making provision for the appointment of a special medical staff for public health work and not dependent on those whose first duty must be to tend the sick.

The whole responsibility of the administration would thus be placed on the central Medical Officer of Health, who should have such assistance as may be deemed necessary.

We understand that there are serious difficulties in the way of carrying out such a recommendation, for not only would it be necessary to repeal the enactment* providing that the Dispensary Medical Officer shall be Medical Officer of Health of his district, but also questions of compensation to existing officers might arise; and furthermore, legislation would be required to enable the Belfast Corporation to appoint one or more Assistant Medical Officers of Health, should they desire to do so.

Nevertheless, we are of opinion that the present system is so unsatisfactory, in practice, that it ought to be displaced in the way we recommend, and in this opinion we find support in the view expressed by the Committee appointed 11 years ago to inquire into the public health and sanitary administration of Dublin.

At the time of our Inquiry the Medical Superintendent Officer of Health, Dr. Bailie, had only recently been appointed. He possessed the statutory qualification required, but he was without previous experience of Public Health administration, except such as he had been able to acquire as a member of the Corporation.

In view of the many complaints which for several years had arisen in connection with the work of the Public Health department, it was of primary importance that a man of wide experience in public health administration in other places should have been appointed, and that a salary should have been offered which would have attracted highly qualified and experienced candidates. This view was very strongly urged upon the Corporation by the Local Government Board, but was not adopted.

We consider that a grave mistake was made by the Corporation in not accepting this advice. This office, for a city like Belfast, is always of great importance, and was especially so in the circumstances of the moment; and it must be remembered that the issues at stake concerned the health of a large industrial city, eighth in population in the United Kingdom.

Unfortunately in Belfast it has been customary to fill this position by electing a former member of the Corporation thereto, and it is obvious that, when a comparatively low initial rate of salary is proposed, and it appears probable that local connections will outweigh special qualifications for the discharge of the duties of the office, the choice of candidates is likely to be restricted.

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* Public Health (Ireland) Act, 1878, Sec. xi.

In investigating the work of the several departments of the Corporation we found our inquiry greatly hindered by the absence of any adequate series of annual reports showing in detail the work accomplished, although individual officers were at all times willing to supply us with whatever information might be compiled from existing records.

Report of the Harrison Committee.

The Belfast Citizens Association furnished to us reprints of a report (known by the name of the Chairman of the Committee, Councillor Harrison, B.L.), presented to the Corporation in October, 1896, by a Committee of their own members, which had been appointed in the preceding August to inquire into the causes of "the high death-rate of Belfast and the unsatisfactory condition of its public health generally."

This report is of importance in relation to the present Inquiry because it expressed the views of a Committee of the Corporation on their own administrative methods.

Moreover, it compensated to some extent a disadvantage under which we were placed by reason of the circumstance that the chief officers of the Public Health Department, viz., the Medical Superintendent Officer of Health and the Executive Sanitary Officer, had but recently been appointed, and were in consequence unfamiliar with the practice of their predecessors at the time to which the report refers.

The report described the grossly insanitary condition of many areas, the prevalence of ashpit privies, the practice of filling up vacant pieces of low-lying ground with the contents of ashpits, the existence of insanitary houses and of unpaved back-passages, and the continued discharge of sewage into certain streams, such as the Blackstaff, Lagan, and Connswater rivers.

It also described the Public Health Administration as being feeble and inefficient, not only because the Public Health Committee were themselves indifferent to their responsibilities, but also because they had not under their control "a sufficient staff of efficient men under proper organisation and discipline."

Control of Infectious Diseases.

Discovery of diseases.

We now propose to consider the methods adopted for discovering the existence of infectious diseases and for their administrative control afterwards. The diseases of this group which are included within the Infectious Disease (Notification) Act, 1889, are thereby provided for. The Act was only adopted in 1897.

But beyond this, and with special reference to measles and whooping cough, which are not covered by the Act, no system seemed to be in operation by which the actual or threatened prevalence thereof might be ascertained. Domestic visitation and especially the interchange of information with school authorities have in towns elsewhere been the means of affording both sanitary and education authorities valuable information regarding the movement of both diseases. In the figures most recently available (Report of the Medical Superintendent Officer of Health for 1906), 29 deaths are attributed to measles, and yet only 62 cases were known by the sanitary authority to have occurred.

The school system of Belfast is described elsewhere, and we recognise the magnitude of the task involved in arranging a co-operative interchange of information with the managers of nearly 300 independent schools. But

questions of importance both to education and public health are concerned in the prevalence of measles and whooping cough, and the introduction of a column in the Register of each school, in which to insert the fact that each child joining the infant standards has or has not had either of these diseases previously, would supply a ready form of reference by which the number of susceptible children in a given school could be at once ascertained when invasion of these diseases is threatened.

Hospital isolation.

In November, 1906, the Purdysburn Fever Hospital of the Belfast Corporation was opened for the reception of patients. It contains 168 beds, and there is an adjacent hospital of a temporary character, for small-pox, containing 74 beds.

Save that provided for small-pox, this was the first fever hospital owned by the Corporation, such patients as were not eligible for admission to the Union Fever Hospital wards being formerly received by the Royal Hospital, before its reconstruction.

In addition to the accommodation at Purdysburn, 200 beds for the treatment of infectious diseases are provided by the Belfast Board of Guardians in the Union Fever Hospital.

We do not regard this administrative separation as desirable. The Corporation should, in our opinion, frankly accept sole responsibility for dealing with infectious disease within the city, and make adequate provision for such cases as require removal to hospital.

King Kerr, 542.

Even with the present use of beds in the Union Hospital the total provision of hospital accommodation is inadequate.

Partly as the result of the inadequacy of hospital accommodation, a large proportion of the cases of infectious disease in Belfast has been treated at home.

Bailie 1439.

The Medical Superintendent Officer of Health expressed the opinion that fully half of the cases left at home were inadequately isolated.

Proportion of cases removed to hospital.

Table XXIII., on the next page shows the number of patients, notified as suffering from enteric fever, scarlet fever, and diphtheria, who were treated at home, and the number who were removed to hospital, in each of the years 1901–06. It indicates that during this period an average of 49 per cent. of the cases of enteric fever, about 29 per cent. of the cases of diphtheria, and only about 25 per cent. of the cases of scarlet fever, were removed to hospital. There seems to be no available record to show whether cases notified as "simple continued fever" were removed to hospital or not, but it seems probable that very few of them were so dealt with.

Having regard to the inadequacy of the hospital accommodation for infectious diseases, and the opinion of the Medical Superintendent Officer of Health that fully half of those treated at home were inadequately isolated, it is desirable to consider the degree of supervision exercised over home cases, and particularly those of enteric fever.

At present this supervision is very inadequately performed.

Each case at home should be kept under constant observation by the staff of the Public Health department until it terminates, and such disinfection of clothing, etc., as is required, carried out by these officers as occasion requires.

Bailie, 1597.

The existing system of supervising infectious diseases requires organisation.

Table XXIII., showing Proportion of Cases of Infectious Disease removed to Hospital.

Year.	Typhoid Fever.				Simple Continued Fever.				Scarlet Fever.				Diphtheria and Membranous Croup.			
	Total No of Cases.	Treated.			Total No. of Cases.	Treated.			Total No. of Cases.	Treated.			Total No of Cases.	Treated.		
		At Home.	In Hospital			At Home.	In Hospital.			At Home.	In Hospital			At Home.	In Hospital	
			No.	% Total.			No.	% Total.			No.	% Total.			No.	% Total.
1901, ...	2,530	1,422	1,108	43·8	1,351	—	—	—	370	299	71	19·2	433	331	102	23·5
1902, ...	1,044	476	568	54·4	730	—	—	—	448	385	63	14·0	432	311	121	28·0
1903, ...	842	375	467	55·4	590	—	—	—	614	479	135	22·1	304	195	109	35·8
1904, ...	530	260	270	50·9	488	—	—	—	635	467	168	26·5	257	170	87	33·8
1905, ...	631	296	335	53·1	569	—	—	—	650	422	228	35·1	234	181	53	22·6
1906, ...	551	276	275	49·9	366	—	—	—	1,193	887	306	25·6	273	189	84	30·7

Bailie, 1879.

The disposal of excreta and disinfection of soiled linen in cases of enteric fever are elementary and obvious considerations, but the latter is left entirely to the discretion of the private medical attendant, and the former, in the case of houses with privies, to the charge of the house cleansing department.

Disinfection.

Any disinfection carried out under the supervision of the Public Health Department during the currency of a case under treatment at home seemed to be limited to the supply of disinfectants, and instructions regarding their use. We consider this insufficient.

Moreover, in our opinion, the methods employed in Belfast with a view to the "disinfection" of premises and persons are both crude and inadequate, and require careful re-consideration.

The Corporation are entirely dependent on an arrangement with the Board of Guardians for the means of disinfecting clothing, and for this they pay £300 annually.

We have already expressed the opinion that the Corporation should accept full responsibility for the hospital accommodation for infectious disease, and this, in our opinion, implies that an equal responsibility rests with them for making adequate provision for the disinfection of clothing. And this disinfection should not be limited to the clothing, which requires to be dealt with on the termination of a given case treated at home, but should cover also whatever is used by the patient during his illness.

The present arrangements for steam disinfection seem to us to be inadequate, and in our opinion the Corporation should provide as soon as possible an efficient disinfecting apparatus of their own.

Sanitary Inspection.

Inspection for nuisances.

From the beginning of this inquiry we utilised every opportunity which occurred for making personal visits of inspection in the several districts of the city, and rapidly satisfied ourselves that the system in operation for the detection of nuisances and for dealing with them was unsatisfactory. We were informed that in many cases nuisances were only dealt with when reported by tenants, and that if they made reports to the City Hall they were liable to receive notice to quit from the house agent.

Bailie, 1050, 1618.
Ward, 11521 *et seq.*

The Medical Superintendent Officer of Health and the Executive Sanitary Officer both stated that the staff of inspectors was insufficient. This opinion the latter officer amplified by stating that, since 1900, the time of the staff had been so completely occupied by supervising the substitution of water-closets for privies that no time was left for the detection of nuisances.

Ward, 11528.
11530.

Some of the sanitary sub-officers were able to "go round" their districts once in two years—some, on the other hand, "had not been round their districts since 1901, that is six years ago." On being asked, specifically, the Executive Sanitary Officer agreed that there was "no effective systematic inspection."

Bailie, 1050.
1052.
1067.

The Medical Superintendent Officer of Health regarded the organisation as satisfactory, but the staff as insufficient. "There were not sufficient officers to carry out the work." House-to-house inspection suffered in consequence.

Here, as in the supervision of infectious disease, the defects in the Public Health department are clearly shown by the evidence of the Corporation witnesses apart from that of other witnesses, whose object, admittedly, was to urge a reform therein.

Articles 14 (3) and 15 (3) of Sanitary Order No. 4 require the Medical Superintendent Officer of Health as regards the County Borough and the Medical Officers of Health as regards their districts, to inform themselves of the conditions affecting health, and to report to the Sanitary Authority. Yet no system of reporting by the latter officers appears to have been in operation "unless they have a complaint to make."

Article 17 (2) of the same Order requires the sanitary sub officers of districts to keep themselves informed in respect of the nuisances existing therein and requiring abatement, but again the insufficiency of the staff was urged as an explanation of the obvious neglect to give reasonable effect to this. The Executive Sanitary Officer stated that there was no effective systematic inspection of districts for the discovery of nuisances. "The whole organisation of the department requires reconsideration." Bailie, 1598. Ward, 11619.

These are the statements of the responsible officers of the Public Health department, but we were informed that the whole question of its organisation had been under the consideration of the Public Health Committee since the beginning of the year 1907. At the close of our sittings a scheme for such re-organisation was handed in. 11621, &c.

Shortly after Dr. Bailie's appointment additional female inspectors were applied for and sanctioned by the Public Health Committee, partly, it would appear, for the purpose of dealing with infantile mortality.

While not undervaluing work in this direction, it may be said that the foundation on which much health improvement rests is purity of surfaces in and around dwellings. Where structural neglect coincides with defective methods of cleansing, the first requirement of any crusade against the causes of infantile mortality consists in putting these things right. The value of systematic inspection for the detection of nuisances and for their removal has not been sufficiently appreciated.

In our visits of inspection we found many cases of choked water-closets full to the brim, of stopped drains and flooded back yards, of yards strewn with garbage and fæcal matter, of uncovered ashpits, of large ashpits which had not been emptied for months; and it must be remembered that in all cases where there are no back passages these ashpits must necessarily be emptied through the houses. We found several rows of ruinous houses, in some of which the upper rooms only were occupied and the lower rooms open and very filthy, and others where the walls were very wet and the windows and doors broken. In many back passages we found the ashpit doors off, and the contents spread about the unpaved passages by dogs and fowls. In one yard a choked drain had been opened and so left for several weeks; in another a stopped drain had not only flooded the yard but also the house passage, cutting off access to the ashpit and water-closet.

Housing.

The housing of Belfast compares favourably with that of other large industrial centres. With rare exceptions, it may be said that there are no tenement houses, and no houses of the kind known in many English towns as back-to-back houses without back yards. In Belfast the houses are through-houses with back yards, and in the great majority of cases each house is occupied by one family only.

The working-class dwellings are mainly of two types—

(1.) Rows of houses with a back yard to each house, the back yards of one row abutting against those of another row without an intervening back passage. These are the older houses, and they have the great disadvantage that there is no access to the yards for removal of ashpit or privy refuse except through the houses themselves. The inspector of house cleansing stated that there are 21,379 such houses.

(2.) Rows of houses built with a back yard to each house and a passage intervening between the rows of back yards so as to afford access to them for the removal of refuse. In the older houses of this type the passages are narrow and do not allow of the passage of carts. In the newer houses a passage of 9 feet is insisted upon. Many of these passages are, however, unpaved, and in the majority of cases the ashpits have doors to the passage which are a source of much trouble, because the doors are often broken off or unfastened, and, especially where they are on the ground level, dogs and fowls have free access to them and scatter the contents in the back passages. Moreover, they are also open to persons who gain a living by ransacking ashpits.

In the great majority of cases of both types, water-closets have been substituted for privies, but the ashpits remain, are often large and uncovered, and only emptied at long intervals.

Double tenancies.

A serious blot in Belfast housing is that in certain cases, as, for instance, in Lepper-street, Harrison-street, and Hardinge-street, the houses which were built for one family are now double-tenanted; one family occupying the ground floor, and a separate family the upper floor. In these cases the tenant of the upper floor has no access to the yard and conveniences except through the rooms of the lower tenant, and when, as frequently happens, the lower tenant is at work and has locked his rooms, the upper tenant may have, for long periods, no access at all to the conveniences in the day time, while at night such access must be almost impossible. This condition of things is in all respects most unsatisfactory, and leads to fæcal matter being stored in the upper living rooms until an opportunity occurs to carry it to the yard. On the ground that the upper tenancies have in effect no sanitary accommodation, these double tenancies should be sternly abolished, or the provision of an external stairway from the upper rooms to the yard should be insisted upon.

This double-tenancy was not alleged to be necessary even on the ground of poverty of the tenants, yet it has been tolerated for years, although the practice is well known both to the Corporation and to the Public Health department. Houses that are inadequately provided with the primary requirements of a civilised existence should be closed as unfit for habitation. In our opinion the Corporation should spare no effort to put an end to this unsatisfactory condition as to housing in Belfast.*

In Section 107 of the Local Act of 1878 power is given to the Surveyor to attach to his approval of the plans of any dwelling-house proposed to be erected, any restriction as to the number of separate dwellings for which the same may be used.

Insanitary Areas.

For the most part the front streets in Belfast are of ample width, but there are many groups of old houses with narrow front streets and other objectionable features, and some groups of blind courts which, in our opinion, ought to be dealt with as insanitary areas and cleared away. Some clearances of insanitary dwellings have already been carried out by the Corporation with the greatest advantage to the city, and we strongly recommend that this policy should be continued. In some cases the sites could, with great advantage, be left open as play-grounds for children.

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* It is worthy of consideration whether bye-laws made under Sec. 100 of the Public Health (Ireland) Act, 1878, would not usefully deal with cases of this kind.

For the clearance of insanitary areas several Acts of Parliament have been obtained by the Corporation, and the following table, submitted by the assistant Surveyor, gives the number of premises thereby removed, the extent of area, and the estimated population affected.

Name of Improvement.	Number of Premises taken.	Area in square yards.	Estimated Population.
Under Act, 1878.			
Royal-avenue, ...	411	40,716	2,466
King-street, ...	35	5,797	210
Corn Market, ...	12	1,239	60
Ann-street, &c., ...	9	1,618	45
Ormeau-avenue, ..	16	73,224	80
Donegall-quay, ...	2	15,953	10
	485	137,947	2,871
Under Act, 1883.			
Green-street, &c., ..	137	10,222	822
East Bridge-street, ..	145	13,887	870
Arthur-square, ...	12	620	10
Rosemary-street, ..	5	172	5
North-street and Gresham-street.	1	327	1
University-road, ..	10	2,770	5
Sandy-row, ...	15	1,686	30
Mustard-street, &c., ..	21	1,480	126
	346	31,164	1,869
Under Act, 1891.			
Stephen-street, Kent-street, &c., &c.	201	9,250	1,206
Under Provisional Order, 1891.			
North-street, ...	103	16,624	515
Bridge-street, ...	3	1,053	3
Wall-street, ...	15	998	90
Unity-street, ...	41	3,820	246
	162	22,495	854
Under Provisional Order, 1897.			
James'-court, ...	15	2,326	90

From the foregoing it would appear that since 1878, 1,209 houses or other premises, having an estimated population of nearly 7,000 persons have been demolished, for city improvement purposes, under the Acts just referred to, and we were informed that others have been removed by the owners at the request of the Corporation.

House Cleansing.

The Belfast Corporation Act of 1899, Section 43, empowered the Coporation to require owners to substitute water-closets for privies, wherever a supply

Substitution water-closets for privies.

of water for domestic purposes exists, and with commendable promptitude the Corporation began to give effect to this provision, with the following result :—

Year.	Houses with		Total.
	Water Closets.	Privies.	
1897	40,859	26,620	67,479
1902	67,788	10,000	77,788

The number of privies has since been further reduced to 2,300.

This work has been carried out under the direction and supervision of the Public Health department, but, unfortunately, without any addition to the staff, and with the result, as expressed by the present Executive Sanitary Officer, that ordinary inspection for the detection of nuisances has been neglected to a serious extent. In our opinion the staff should have been increased to the extent necessary for the purpose, so that the work of sanitary inspection should not suffer.

For even casual visiting revealed repeated illustrations of surface pollution of the soil from overflowing ashpits, of ashpits defective either because they were uncovered or were without doors, of passages flooded or in need of paving ; but it was frequently difficult accurately to apportion the blame between the departments which were severally responsible for the maintenance of structure and for the removal of refuse, and the tenant who found in the foul atmosphere which surrounded the place an excuse for not attempting to use the ashpit at all.

M'Bride, 11837. It does not appear that the Public Health department were unaware of these things, for it appeared from the evidence of the Inspector of Cleansing that structural defects of the kind just alluded to, observed by the men engaged in emptying ashpits, were duly noted and information forwarded to the Public Health office, although this arrangement was only systematised and a register kept from 17th April, 1907, during our sittings.

It was urged by several witnesses that the want of cleanliness, apparent in many of the districts of the City, was due in large measure to the careless and dirty habits of sections of the people, and we fully recognise the considerable part which undisciplined habits play in adding to the sum of uncleanliness.

House cleansing. But one of the principal functions of a Public Health department is to inculcate cleanliness, and they can best do this by themselves setting the example. In other words, it is of little avail to proclaim the necessity for domestic cleanliness unless this is accompanied by evidence of earnest endeavour on the part of public health authorities to keep the surroundings of houses in a correspondingly clean state. It is more than a coincidence that the dirtiest houses internally should mostly be found in association with the dirtiest back passages and with overflowing ashpits. It was said by several of the official witnesses that complaints as to house cleansing are invariably attended to when received. It is obvious that this is insufficient ; to wait for complaints places the initiative at the wrong end, and tends to bring down the standard of departmental policy to the level of local tolerance.

King Kerr, 832. We were frequently told during our visits of inspection that intervals of about three months occurred between successive emptyings of ashpits in several localities. The accumulation of vegetable and organic refuse for long periods in ashpits situated in small and confined back yards in close proximity

to dwelling-houses, constitutes a serious nuisance, and is fraught with grave danger to public health. Effective public and domestic scavenging is of primary importance. Indeed, were it at all necessary to bring the insanitary condition of Belfast within the scope of a general statement, defective methods of cleansing and absence of systematic inspection for the discovery of nuisances, would claim precedence over almost all others.

We are of opinion that no remedial measures regarding ashpits short of their abolition will be satisfactory, and we recommend that the Corporation should take steps to substitute for the present system of built ashpits, one of small ashbins, from which the removal of ashes and house refuse should be regular and frequent.

While a daily service may be regarded as in some circumstances a counsel of perfection, it becomes a necessity in certain districts of most cities, and is in many put into practice.

The removal of refuse, at least twice a week, from small and confined back yards in the poorer and more congested areas of the city is, in our opinion, necessary, and removal of refuse at least once a week in the less congested areas should also be carried out. The additional expense involved by the regular and frequent removal of refuse from the dwellings of the people would be amply repaid by the advantage to the public health of the city.

Having regard to the urgent necessity that exists for improvement in house cleansing in Belfast, no time should be lost in carrying out new arrangements on the lines we have indicated.

We may call attention to the fact that it is provided by Sec. 26 (sub-section 2) of the Public Health Acts (Amendment) Act, 1890, that —

> "Where a local sanitary authority themselves undertake or contract for the removal of house refuse, they may make bye-laws imposing on the occupier of any premises duties in connection with such removal, so as to facilitate the work which the local authority undertake or contract for."

Back passages.

Section 44 of the Act of 1878, empowered the Corporation to insist if so advised that "every new street intended as the principal or front access to a continuous line of buildings shall have provided and set out in connection with it one or more back or transverse streets or roads in such manner as to afford access for carts to the back of every house in such continuous line of buildings in the new street," and by Section 6 of the same Act the definition of "street" was expanded to include "passage" (whether a thoroughfare or not) if open to the public, and was made applicable to all existing as well as new streets. M'Bride, 11893.

Over such passages, therefore, it would appear that the Corporation have powers equal to those which they possess over streets in general.

Many of the back passages, however, even where houses are built on both sides of them, are unpaved, and cannot be effectively cleansed. Moreover, as their primary object is to provide access for the purpose of emptying ashpits, they are exposed to recurring pollution from this operation as well as from defective ashpit doors and the carelessness of tenants. The obvious remedy is to finish them as streets and cleanse them efficiently. But when we inquired why so many were allowed to remain unfinished, no satisfactory reason was advanced. In this state they are, admittedly, objectionable.

The only explanation forthcoming was that the owner is occasionally poor, and this is permitted to outweigh a statutory requirement made in the interest of the public health.

Counsel for the Corporation contended that all back passages, laid out prior to 1878, were private passages. If the existence of a door or other barrier against the entrance of the public to these passages, excludes certain of them from the scope of the Corporation's power over them as streets, they are still within the purview of the Public Health Acts, should nuisance arise.

Vigorous action is required to secure that all back passages built on both sides shall have smoothly paved surfaces, kept in good order, and systematically cleansed.

Separation of house from street cleansing.

We regard it as a defect in the administration that house cleansing should be under a separate department from that which undertakes the cleansing of streets. In our opinion, both functions should be combined in one department.

Refuse Disposal.

Mr. M'Bride, Superintendent of house cleansing, who works under the direction of the Health department, has also under his charge the refuse destructors and tipping grounds.

11820.

The sum expended in cleansing has not increased during the last nine years or so, and this was explained to be due to the substitution of water-closets for privies.

M'Bride, 11958, 11963.

The Superintendent thus stated the distribution of the total refuse for 1905 :—

No. of loads sent by rail direct to farmers in country,	15,067
No. of loads sold to farmers from Stewart-street Depot,	8,805
No. of loads sent to destructor, . . .	11,212
	35,084
No. of loads sent to tipping grounds, . .	66,816
Total, . .	101,900

We were informed that about two-thirds of the total refuse is disposed of by the Corporation in filling up sloblands or tipping grounds within the city; that something less than one-tenth is dealt with by the destructor; and that almost the whole of the privy contents, amounting to over 15,000 loads, is sent direct to farmers, who pay 6*d*. a load for it. This was scarcely consistent with the accumulations observed by us at Stewart-street depôt, which is situated in the centre of the city, and further examination disclosed the fact that, as the farmers cannot take delivery save at two periods of the year, much of the material ultimately to be used by them is stored at Stewart-street in the intervals.

Stewart Street Depot.

Sorting takes place at this depôt, matters unfit for manure being there taken out of the privy refuse, and ultimately removed to the tipping grounds or the destructor.

This storage and sorting of large quantities of offensive refuse in the heart of the city should not be continued. If retained at all, the depot should become a small sorting station whence each day's yield would be despatched before that of the next arrives.

M'Bride, 11972.

11982

It was stated that the material sent to the tipping grounds is "good clean dry ashes," but this did not correspond with the presence of much putrescible matter observed by us on visiting these places, and the Superintendent of cleansing ultimately agreed that "a large part of the matter now sent to the tipping grounds ought to go to the destructor."

Tipping Grounds.

R. M'Bride, 12024.

The tipping grounds are situated at Victoria Park, the sloblands, Ravenhill, also known as London-road, the football ground, Lisburn-road, and the Bog Meadows.

We found some of these in a very offensive condition, and saw children playing on them and picking out matters from the foul rubbish.

The practice of tipping offensive matter on areas within the city, which may, and almost certainly will in due time, be used as building sites, is objectionable.

It would appear that the Corporation, by their own action in filling up these sites with anything which is not either virgin soil or furnace clinker or ashes, are adding to the initial cost of any building which may in the near future be erected upon them, by the sum necessary for the excavation.

For a great many years there have been complaints at Belfast about the building of working-class dwellings on sites, the level of which has been raised by the tipping of ashpit refuse which had not been removed before building.

We are of opinion that this practice should be discontinued.

Increase of destructor plant necessary.

The existing destructor consists of a 12-celled Goddard-Massey and Warner plant. It was erected in 1901, and each cell is capable of dealing with ten tons of material daily. Each may also be fired independently, but none can be repaired without stopping all. Eight only of these cells were in operation when our Inquiry began, but the need for repair became so urgent that, as the summer advanced, all of them had to be thrown out of use, and no destruction of refuse could be undertaken. 12018–21.

The inadequacy of the present installation to deal with the volume of material requiring destruction was admitted, but on the present site no extension is, in the opinion of the Superintendent of cleansing, possible.

We strongly recommend the provision of one or more additional destructors, and consider that this ought not to be delayed.

Clinkers from the destructors, together with clean ashes, could be safely used for levelling up sites. For the reclamation of slobland a less pure material would be permissible, but it should be deposited after a definite system, and the working face restricted within reasonable limits.

All other refuse, except that which can be sold as manure with immediate removal from the city, should be burnt in the destructors.

Section VIII.

MILK SUPPLY.

The distribution of milk in Belfast.

The purity of the milk supply is a matter of extreme importance, and has fitly formed the subject of legislative interference. It is an indispensable article of food, and practically forms the exclusive diet of a large proportion of the most susceptible class of the population, including infants and invalids.

The consumers of milk in Belfast naturally look for protection to the Sanitary Authority, and expect that, so far as the present state of the law allows, it will be made impossible for vendors to distribute milk that may be the medium of conveying disease.

In Belfast a large proportion of the purveyors and small retailers of milk reside in poor localities. Milk is apparently sold in all kinds and conditions of shops, and in very many cases from uncovered milk pans. The contamination of milk exposed under such circumstances is obviously unavoidable. If an uncovered milk pan is exposed to the dusty air of a small provision shop during the day, as we have repeatedly seen, it must necessarily absorb a large amount of dirt, dust, and other deleterious matter.

Dairy shops, properly so-called, where milk and butter products only are sold, are the exception in Belfast.

There are 246 registered cowsheds and dairies in the city, and in no fewer than 70 of these premises pigs are kept, in some places quite close to the cowsheds. In one instance we found pigs in the same building with the milch cows. From a public health point of view this cannot be regarded as satisfactory, and, in view of the fact that every possible care should be taken to ensure the distribution of a clean milk supply to the public, it should not be permitted.

14681-14684.

A large quantity of milk is delivered daily in Belfast from outlying districts, but the Corporation, like other local authorities under similar circumstances, have no control over these sources of supply, except in so far as the Infectious Disease (Prevention) Act enables them to take action to prevent the dissemination of notifiable infectious disease in the city. It was estimated by one witness—a purveyor of milk—that 25,000 gallons were consumed each day in Belfast, and that out of this quantity at least 19,000 gallons came from districts outside of the city.

The transit of milk by the Railway Companies to Belfast was also stated to be unsatisfactory. Milk is placed in the same vans with fish, and we had evidence that sheep and dead meat carcases were conveyed in the same railway trucks with milk.

Construction and ventilation of city cowsheds.

Evidence was given by Mr. James Gregg, a Veterinary Surgeon, who is also a member of the Corporation, in reference to the construction of cowsheds in Belfast. His evidence went to show that the construction of many of the cowsheds is of a very inferior character, and that no attention is paid to the question of ventilation. He stated that a great many cow-keepers, in order to force the yield of milk, closed all the means of ventilation. In several instances that came under our notice we found the methods of ventilation insufficient, and the atmosphere of the cowshed close and oppressive. The danger incurred by the consumption of milk from cows so kept is obvious. In one byre we found four cows with an average of 297 cubic feet of air space for each. In another five cows with an average of 448 cubic feet of air space per cow. In a third byre there was an average of 480 cubic feet per cow. The theory that a milch cow kept in a close and foul atmosphere and in the dark is "the better milker" is evidently implicitly believed in by many cow-keepers in Belfast.

It was stated in evidence that hitherto very little attention had been given to the question of the frequent removal of manure, the cleanliness of the milker's hands, and the cleanliness of the cows' teats and udders. It was, however, stated that recently a considerable improvement had been effected in this regard.

It may be desirable here to give an example of a cowshed and dairy premises in Belfast that came under our notice. In this dairy yard and quite close to the byre there was an accumulation of manure estimated at five tons, which apparently had not been disturbed or removed for a considerable time. The flooring of the byre itself was of "cobbles" and was caked with hardened manure. There were two openings on the same side as the door leading into the cow byre. There was no through ventilation, and the lowness of the roof emphasized this defect. There were 39 pigs kept at the end of the byre and under the same roof as the milch cows, which were ten in number. There was no light at this end excepting what came through a small hole in the gable. The dairy premises were surrounded by dwelling houses. The odour from this large number of pigs was most offensive.

In several instances we found cows whose flanks and tails were very filthy, and which had not evidently been groomed or cleaned for several weeks. The production of milk from cows housed under such conditions, and with such marked insanitary surroundings cannot be too strongly condemned, and emphasizes the necessity that exists for a more rigid enforcement of the regulations.

It was made very apparent to us that the regulations in force under the "Dairies, Cowsheds, and Milk Shops Order" require to be more strictly administered. Although the regulations state that manure should not be allowed to accumulate on dairy premises for a longer period than two days, we noticed in several cowsheds and dairy yard premises large heaps of manure, evidently the accumulation of very many days.

The regulations as to ventilation and cubic space are also not strictly enforced, and we had evidence of this in several instances where the ventilation was very indifferent, and where the number of cows was in excess of that permitted by the regulations. In some instances we happened to visit dairy premises at milking hour, and the hands of those eugaged in milking were not clean. In one or two cases the hands of the milker could only be described as "filthy."

Several of the dairy premises have no adequate provision for the cleansing of milk vessels, and there is an absence of special milk houses or pantries where milk might be kept or stored temporarily for cooling purposes. It is the custom in Belfast when milk is drawn from the cow to immediately strain it in the dairy yard and deliver it to the public without submitting it to a process of cooling. This method cannot be regarded with approval, or as complying with the modern system of dealing with milk supplies intended for daily consumption.

Another custom that cannot be too strongly condemned, but which, apparently, has hitherto been a common one in Belfast, is that of conveying buttermilk barrels on carts laden with manure, as also the custom of collecting feeding refuse for pigs in dairy carts. We were informed that both customs are being discontinued under pressure by the Corporation officials.

So far as structural reforms are required, there already exist the Regulations under the Dairies, Cowsheds, and Milk Shops Order, issued by the Local Government Board, which only require stringent application to become effective.*

* Since our sittings closed a most important General Order with respect to Dairies, Cowsheds and Milk Shops has been issued by the Local Government Board for Ireland (in pursuance of the Contagious Diseases (Animals) Acts, 1878 and 1886), in which many important regulations are laid down on questions which formerly were only dealt with at the option of the local sanitary authorities, the majority of whom took no action in the matter. The new order applies to the whole of Ireland, and comes into force on 1st May, 1908, and it may be anticipated that it will be productive of most beneficial results.

Insanitary condition of dairy premises.

The Inspector of cowsheds and dairy yards, who had only been in office for some months, stated that, recognizing the unsuitable conditions of many of the cow-sheds and dairy premises, he had served 160 notices relating thereto. Since his appointment he found many cowsheds in a very bad state. They were not kept clean, and the drainage was very bad. He fully recognized the necessity for more frequent removal of manure.

As further evidence of the insanitary conditions prevailing, he had during his short term of office also found it necessary to institute forty prosecutions for overcrowding of cattle, filthy cowsheds, dirty hands of milkers, and the carriage of refuse in milk carts.

We fully recognise this as praiseworthy activity, but it was made quite apparent to us on the occasion of our visits that a vigorous crusade will be necessary to bring cowsheds and dairy yards in the city to a satisfactory condition.

Return showing the number of Cowsheds and maximum number of Cows in the several Dispensary Districts for the City and County Borough of Belfast.

District.	Cowsheds	Maximum number of Cows
1. Dock, ...	2	10
2. Hospital, ...	14	97
3. Shankhill, ...	22	311
4. Workhouse, ...	35	372
5. Millfield, ...	7	198
6. College, ...	21	428
7. Greencastle, ...	6	102
8. Ligoniel, ...	28	407
9. Falls, ...	24	378
10. Woodvale, ...	21	331
11. Ravenhill, ...	44	476
12. Newtownards-road, ..	5	40
13 Ballyhackamore, ...	17	222
Total, ...	246	3,372

Very many of these cowsheds are so situated, in densely populated localities, and immediately surrounded by dwellings, that it is impossible to expect that milk can be produced under hygienic conditions.

The staff employed for the inspection and supervision of the dairies, cowsheds, and milkshops does not appear to us to be adequate having regard to the vitally important questions surrounding the production of a pure milk supply.

Besides the registered cowsheds and dairy yards, there are milkshops of all sorts and conditions, whose number is very great.

For this important branch of the Public Health administration there are two officers, an Inspector of Cowsheds, and an Inspector of Milkshops. This staff is not sufficient to properly supervise the large production and sale of milk in Belfast, which specially require an active and constant supervision in every detail.

Tuberculous milk.

Mr. Gregg expressed the opiuion that about two per cent. of the milch cows in Belfast suffered from Tubercular disease of the udder, and, that having regard to the fact that the latest return shows that there are about 3,372 cows in the City of Belfast supplying milk to the public, it is obvious that tuberculous milk in no inconsiderable quantity finds its way to the consumers.

If the above opinion be correct, and taking the acknowledged yield of milk from a cow all the year round at five quarts per day, it would appear that, approximately, between 80 and 90 gallons of tuberculous milk is distributed daily in Belfast, exclusive of the milk that comes into Belfast from the rural and outlying districts.

Mr. Jordan, the Veterinary Surgeon to the Corporation (whose appointment is of recent date, April, 1906), from his brief experience expressed the opinion that five per cent. of Belfast cows suffered from generalized tuberculosis.

Dr. M'Caw, Senior Physician to the Hospital for Sick Children, expressed himself strongly in favour of the establishment of "Milk Depôts" in Belfast.

Several medical witnesses—notably, Sir John Byers, Professor Lindsay, Dr. M'Caw, Dr. Dempsey, and Dr. Caldwell—expressed the opinion that the Corporation should at the earliest possible moment take steps to obtain powers of control and supervision over the milk supply coming into Belfast from rural districts.

In its broadest sense this implies that the Corporation of Belfast should accept responsibility for enforcing the Dairies, Cowsheds, and Milkshops Order and the Regulations made thereunder in the district of any local authority from which it obtains any portion of its milk supply.

The argument on which this proposal is based—and it has been advanced elsewhere—is that the consumer of milk should be able to prescribe the conditions under which it is produced, and that if he obtains healthy conditions for, and freedom from disease in, the milch animals stalled within the area of his own local authority, he should be able also to insist upon a reasonable equivalent in the case of the rural cowsheds from which portion of his supply is obtained.

So far the contention is reasonable enough, but the expediency of the method by which it is proposed to give effect to it is, we think, open to serious objection.

One of the most prolific causes of disease, and especially of tuberculous disease in our milch herds, as in man, is the insanitary conditions under which they are housed, and reform in the housing of dairy stock is one of the first requirements of a pure milk supply.

Looked at in this light, the proposal to control the outside sources of supply presents a difficulty at the beginning, for reform in the structure of cowsheds must lie with the local authority in whose district the cowsheds are situated, unless administrative confusion is to arise.

And, in like manner a similar result would follow even where the power of control is confined to the inspection of milch animals, unless this were further restricted to cases where there was reasonable ground for believing that disease was being caused by the milk of a particular herd.

Moreover, it is obviously bad policy to set up machinery for preventing distribution of milk that is pathogenic to man among a given community without making provision to ensure that such milk shall not be distributed amongst some other community. There can be no doubt, and, indeed, there is a consensus of opinion now, that this difficult question requires further general legislation to adequately deal with it, and that one of the chief objects of such legislation should be to ensure the prevention of the distribution *anywhere* of milk that is capable of causing disease in human beings. Meanwhile, there is no reason why the Corporation should not endeavour, in co-operation with the adjoining local authorities, to improve the conditions under which milch cows which supply milk to Belfast are being kept.

Section IX.

THE MEAT SUPPLY.

The greater portion of the cattle and sheep intended for the meat supply to Belfast is killed at a public Abattoir under the supervision of the Corporation. There are still four private cattle slaughter houses and three pig slaughter houses.

22026. The situation of the Abattoir cannot be regarded as satisfactory. Evidence was given that complaints had been made by the butchers using it as to its proximity to the Gas Works and Chemical Works. In view of the present surroundings, and the restricted and insufficient accommodation now available, more especially for the slaughtering of sheep, the Corporation should, at the earliest possible moment, take steps to provide a more modern and commodious Abattoir on a more suitable site.

The number of animals slaughtered at the Abbatoir each year is very large, the totals for the years 1904, 1905, and 1906 having been 50,784, 59,003, and 58,238 respectively.

About 200 butchers use the Abattoir for slaughtering purposes.

Mr. Jordan, the recently appointed Veterinary Surgeon, visits the Abattoir each day, inspects cattle before slaughter, and examines carcases after slaughter.

There are four Meat Inspectors, one being continually on duty at the Abattoir, and the others are on duty in the city. In addition to this staff, there is a Superintendent and Clerk of the Markets, who supervises and controls the work of the Meat Inspectors.

21988. The Corporation have the power to close the private slaughter houses in the city, and they should exercise this power, and thus ensure that the entire meat supply, and the slaughtering of cattle, sheep, and pigs within the city boundary would be under the same supervision.

In connection with the Abattoir there are some firms who are permitted to use private quarters for slaughtering purposes. This is also a custom that should be abolished.

The carcases of cattle and sheep that are slaughtered outside of the city boundaries and intended for sale in the city are brought for inspection to a special market for that purpose. It was stated in evidence that only the carcase is produced for inspection, and that none of the internal organs
22042. are submitted for examination. It will be seen by the following Table that the number of cattle and sheep slaughtered annually outside the city boundary is very large :—

CATTLE AND SHEEP SLAUGHTERED OUTSIDE THE CITY BOUNDARY, AND INSPECTED IN MEAT MARKET

	Cattle	Sheep.	Seized.
1901	1,823	2,082	37
1902	3,803	2,608	48
1903	4,919	2,722	51
1904	1,820	4,565	65
1905	1,172	3,478	35

22114. All imported foreign meat arriving by sea is stated to be inspected, but this inspection does not seem to be very satisfactory, for, according to the evidence, the city authorities have no power to inspect until the carcases have left the Harbour Commissioners' premises and have been dispersed.

Section X.

SCHOOLS.

Much evidence was brought before us as to the unsatisfactory condition of Belfast schools. We ourselves visited a considerable number, and were able to satisfy ourselves that while some are quite creditable and others are good, many are very unsatisfactory indeed.

Professor Lindsay, M.D., speaking from personal experience, described some of them as "filthy dens" and "simply disgraceful," and expressed surprise that a wealthy city should not only permit the use of such schools, but compel the children to attend them. He quoted a report dated 1900 by Dr. Beattie, one of the Inspectors of the National Board of Education, in which he says:—"No other city in the world of the wealth and enterprise of Belfast would tolerate such primitive and unsanitary houses as are many of the Belfast schools."

Sites.

The situation of many of them is quite unsuitable, in narrow streets, hemmed in by dwellings or other buildings, where it is impossible to provide a playground. Often the external aspect is squalid, while the inside is dirty and unwholesome. The sanitary arrangements are often very bad; some were found in a filthy state, while generally the lavatory accommodation is inadequate or wholly absent.

In his report of January, 1906, Mr. P. J. Kelly, Inspector under the National Board of Education, says:—"It is a curious fact that a prosperous and progressive city like Belfast, rivalling as it does the most thriving seats of industry in Great Britain, should, nevertheless, be the most backward part of the British Isles in the matter of school accommodation. I venture to say that the poorest counties of Ireland are better off in this respect."

Professor Lindsay said that 30 per cent. of the schools in Belfast were without playgrounds. The result is that children are mostly turned into the streets for the play hour. Some masters object to this, and do not allow the pupils to go out at all, so that in those cases the children are actually in the schools from 9.30 to 3. Mr. Kelly stated that in his district, that part of the city on the Antrim side of the river, 40 per cent. of these schools were without playgrounds, while 20 per cent. more had inadequate playgrounds.

Class-rooms.

The want of a sufficient number of class-rooms, according to Mr. Kelly, is a specially weak point of Belfast schools. In many there are no class-rooms, or there is only one class-room, while in others, where there are several, they are miserably inadequate in size. Sometimes this is the case where the schoolrooms themselves are of ample size, and often too large. "two to six teachers teaching in the same room under conditions which to him (Mr. Kelly) would be well-nigh intolerable." "They find it so difficult to teach in one room that they try to cram the children into any place. I know of one where children were crammed into the little cloakroom."

Mr. Kelly gave a large number of instances in which he found the number of children much in excess of the proper accommodation, but he also points out that school space is badly distributed in Belfast, and that there are schools where the accommodation is in excess of the local need. This is probably due to the shifting of the population from the centre to the suburbs. He says:—"Allowing 9 square feet per pupil in average attendance, the floor space is inadequate in 25 per cent. of the schools." "The Commissioners now expect that there should be 10 square feet of floor space per unit of the mean between the average attendance and the average on the rolls, and on this basis the percentage of overcrowded schools will be still greater." The average floor space per pupil in attendance is for all Belfast 11·3 sq. ft., and for the County Down side only 9·2. Dublin gives 13·1 sq. ft.; Cork, 13·1; Derry, 12·3; Limerick, 14·7; Waterford, 16·3; and Ireland as a whole, 14·7 sq. ft.

It may be useful to give an extract from Mr. Kelly's evidence in order to show that overcrowding is by no means limited to a few cases, and that many of the class-rooms are either not heated at all or are insufficiently heated, and are also insufficiently ventilated. Where rooms are not heated

it is natural that the windows should be kept carefully closed. (15822.) "I found forty pupils in a class-room 18 feet 3 inches by 13 feet, and the ventilation was poor. In the same school there were fifty-nine pupils in a room 19 feet by 9 feet, the air being very bad. In this school the average attendance was only about 145, whereas there was accommodation for nearly 200 pupils. The next school I found forty-nine infants in a room 14 feet 6 inches by 10 feet. In another school there were over eighty infants in a class-room 21 feet by 14 feet, though the floor space as a whole was fairly ample. In another school there were two class-rooms, each 12 feet 6 inches by 10 feet, and there were usually from twenty-five to thirty pupils in each. The doors were kept open for ventilation, and neither of the class-rooms was heated. In another school the class-room is a mere garret. There are no windows, just two skylights, and there is no heating of any kind. In another school the class-room is similar to the above, but is heated by an oil stove. The stairs are so steep and narrow and winding that you might imagine you were ascending a round tower. In another school I found sixty-six pupils in a room 16 feet 8 inches by 16 feet 5 inches, and the room not heated. In another school, which is vested in trustees, there were ninety-two infants in a room accommodating forty pupils. In another there were as many as forty-seven fifth standard pupils in a room 16 feet by 11 feet. In the next school I found fifty-seven pupils in a room 14 feet by 11 feet 9 inches. The door and the windows were shut. The windows could not be opened because the wind was too strong. There was no means of heating this room, and the lighting of an adjoining class-room was so dim that the gas had to be kept lit. In this school the average attendance was not quite 100, whereas there was accommodation for 230 pupils.

"In the next school I found as many as fifty-one pupils in a room 17 feet by 8 feet. The three class-rooms were heated by gas stoves. The lighting and ventilation of one was very unsatisfactory, and the door had to be kept open for ventilation. In the next school there were twenty-five pupils in a room 13 feet 2 inches by 11 feet 5 inches, and the ceiling, which was a horizontal one, was 6 feet 11 inches. There was only one window and the lighting was bad. It is used only for one lesson in the day. In this school there is accommodation for about 179 pupils, whereas the average attendance is not quite 100. In the next school I found seventy-eight infants in a room 23 feet 4 inches by 12 feet 6 inches. The ventilation was very bad, so bad that I remained in the room only a few minutes, in the class-room, or, to be more correct, I stood at the open door.

"In the next school there were fifty-four infants in the room, which was 23 feet 4 inches by 12 feet; there were two small windows, opening from the top only. The door had to be kept open for ventilation. In another school I found thirty-five pupils in a room 18 feet by 8 feet 6 inches, only one window, and the ventilation was not at all satisfactory. On the same day I found forty-six in another class-room 18 feet by 10 feet; there were no means of heating it, and the lighting was defective. In the next school there were ninety-six infants in a room 27 feet by 13 feet 4 inches; and 134 infants in a room 27 feet by 26 feet 8 inches. The infants were packed as close as they could be on galleries, which made the congestion much worse than might be inferred from dimensions of the class-room.

"In the last school the average attendance was 225, and there was accommodation for 342. In the next school there were 82 infants in a room 25 feet by 20 feet. In the next school I found 50 pupils in a room 16 feet by 15 feet; there were windows on one side only, and the lighting was defective. In the next school there were 110 pupils in a room 25 feet by 20 feet 8 inches.

"I have a number of cases now—in the first, the accommodation was 22, and 50 present; next, accommodation, 71, and 115 present; next, accommodation 22, present 52; next, accommodation 26, and 48 present; next, accommodation 28, and 60 present; next, accommodation 20, and 50 present; next accommodation 21, and 42 present; next accommodation 24, and 61 present; next accommodation 22, and 78 present; next accommodation 25, and 44 present; next accommodation 47, and 86 present; next accommodation 35, and 78 present."

Heating.

It would seem that in many cases the heating of the schools is at the charge of the teachers, the managers having no funds for the purpose; and that the cost of sweeping and cleaning has in some cases to be borne by them. Even where there are suitable stoves, the want of funds often prevents them from being used except very late in the season.

Mr. Kelly says :—"I have often felt so cold in Belfast schools that I have had to wear my overcoat during the day," and it must be remembered that many of the children have no shoes or stockings.

No organisation.

Thus while some schools are too large for present local needs, others are quite too small for the numbers crowded into them, and while some have ample funds, others are starved. There is no organisation, no unity of action, and no attempt whatever is made to bring it about. There is no local controlling body to consider the educational requirements of the city as a whole, or even the needs of certain sections of the population.

"It should no longer be open to any individual to dump down a school in any quarter of the city, regardless of the real educational needs of the locality, and the best means of supplying them. It is high time to cry 'Halt' to a system of uncontrolled individual action, which has been the bane of education in Belfast."

Central Board of National Education.

There is, indeed, the Central Board of National Education, which pays the salaries of the teachers in all these elementary schools, and which is prepared to advance two-thirds of the initial cost of the buildings and furniture, provided these are vested in the Commissioners of National Education or in trustees, in which case the plans must be submitted and approved by the Commissioners ; but most of the schools are not so vested and are the property of private individuals, or more frequently of Church congregations, who find the money for providing them. In some cases they obtain loans from the Commissioners, which involve some control by them of the plans, but in a great many cases, loans are not sought.

Vested schools.

Mr. Kelly says that in Belfast less than 20 per cent. of the schools are vested, although vested schools, receiving two-thirds of their initial cost from central public funds, may remain under denominational management. "Of 39 schools, 9 are vested in the Commissioners and are under Presbyterian management, and 30 are vested in trustees. Of these, 17 are under Roman Catholic management, 9 under Presbyterian management, and 4 under Methodist management."

Mr. Gray, in his evidence, points out that in Shankill parish (the greater part of Belfast) two schools are under official management, viz., the Model School, at which there is a boys', girls, and infants' school, and the workhouse. Of the others there are lay managers for 51 and clerical managers for 190.

Mr. Kelly attributes the relatively small numbers of vested schools in Belfast, among other reasons, to the desire of the managers to be free from the restriction placed upon the use of vested schools outside of school hours.

These congregational schools are not built solely for education ; they have to serve a double purpose, as schools by day and meeting rooms at night for Boys' Brigades, Bands of Hope, concerts, prayer meetings, &c. In these conditions, with schools provided by private effort, it is inevitable "that everything should be done in a cheeseparing way." They have not the necessary funds to do the work well.

The fact that so many of the schools are erected for congregational purposes, and that each congregation desires a school under its control, leads to the number of the schools being needlessly multiplied. It is common to see several "National schools" in close proximity in one street.

On the other hand, Mr. Gray observes—"The apathy of the public would be disastrous but for the clergy getting up the schools." No one else seems to care to do anything.

Too many schools.

There are too many schools in Belfast. Mr. Kelly states:—"We have far more schools in Belfast than we require. In the district between Shankill and Crumlin, I should say that at least a dozen of the schools should be done away with and replaced by central schools."

School age.

It may here be incidentally pointed out that the school age of Belfast is between three and fifteen years. Little good can be done with those from three to five years old, but many mothers are employed in mills, the parents are away all day, and the schools, so far as these little ones are concerned, are merely day nurseries. The children go to school earlier and leave earlier than in other places.

Now, what are the responsibilities of the Corporation of Belfast in connection with the schools of the city, their needless multiplication, and the unsatisfactory state of so many of them? There is in Belfast no local controlling body, nor are any powers vested in the Corporation for the control of elementary education such as the Act of 1902 brought about in England.

The Corporation of Belfast are expected to see to the compulsory attendance of the children at school, but have practically no control over the schools to which they compel them to go. The local rates contribute nothing to primary education.

Municipal control.

The Corporation have powers under the Technical Instruction Act, and have recently built a splendid technical school.

Their powers of supervision over the elementary schools are limited to those given them by the Public Health and local Acts; and if there is overcrowding or any insanitary condition amounting to nuisance, they can deal with a school as with any other building. We are without evidence that substantial effort has been made by the Corporation to exercise the powers referred to, but it was explained that the Corporation are constantly met with the difficulty that managers of schools say they have but very limited resources, and that to insist on alterations may lead to the closing of the schools.

Since the adoption of building bye-laws by the Corporation, school plans have been submitted to the Surveyor's Department. The local Act of 1878, section 83, provided that "every schoolhouse, or building erected to be used as a school, after the passing of this Act, and every building altered to be so used, shall have a yard or playground of such dimensions as the Corporation shall approve." This seems for many years to have remained a dead letter, but in 1894 the Improvements Committee of the corporation issued a regulation that for schools thereafter to be erected or enlarged, playgrounds should be provided of an area equal to $1\frac{1}{2}$ times that of the floor space of the school. In his evidence Mr. Munce, the Assistant Surveyor, stated that since this came into force the Corporation have in every case insisted on playgrounds on this scale as a condition to the passing of the plan; so that the schools without playgrounds or with inadequate playgrounds are seen to be those built before 1894.

In regard to these, the Corporation have very little power and are at times discouraged by the laxity of the central department, and it is urged that if the Commissioners of National Education are satisfied the Corporation should not object.

Control by the National Education Board.

It would seem that the Commissioners also feel unable to press their own regulations for fear of closing the schools. Mr. Kelly gave a case where, in consequence of the Commissioners instructing him to insist on 6 square feet of floor space per pupil on the rolls, over 100 children had to be sent out of the school into the streets, and he added, "If we acted strictly the number would be nearer 200."

Recommendations

It is not for us to say whether the Commissioners of Education should or can be more strict in enforcing their own regulations and refusing annual grants to schools which obviously contravene them. They may have difficulties to contend with owing to the existing law, which permits buildings to be occupied as schools before their approval is obtained.

But we think it in the highest degree desirable for the Corporation to rigorously exercise, in respect of the insanitary conditions at present existing, in the form of defective heating, ventilation, cubic space, latrine accommodation and playgrounds, the powers which they at present possess under the Public Health and Local Acts dealing therewith; and to similarly require that their own regulations shall be observed in all plans of new schools submitted for approval.

It may happen that by this policy some schools would be closed and the erection of some proposed schools be prevented, but such a result might bring about a useful crisis and tend to the new legislation which the evidence shows is so urgently required.

The bad results hitherto obtained appear to have been largely due to a division of responsibility between the Sanitary Authority and the Commissioners of National Education, and the absence of well-considered regulations.

In our opinion no real progress can be made until the ratepayers are called upon to bear a share of the cost of the schools, and powers are vested in the Corporation or other rating body for the control of elementary education.

In this connection we think it useful to make the following further quotation from Mr. Kelly's evidence. He says:—

"I have been acting as Inspector of Schools in Belfast for nearly six years, and as I have been brought into intimate relationship with many phases of the schools question, I shall take advantage of the fact that the occasion is privileged, and give you my opinion for what it may be worth.

"In approaching this problem we have to take cognisance of two important and fundamental facts. The first is that the Roman Catholic managers have a rooted objection to any interference with their powers as managers. The second fact is that many of the Protestant managers, both lay and clerical, would be quite willing to submit to local control, provided adequate facilities were afforded for imparting religious instruction in the schools. I may add that about 25 per cent. of the schools under Protestant management are under lay managers, and no Roman Catholic layman manages a school in Belfast. Now, we must take facts as we find them, and it becomes desirable, therefore, to differentiate in this matter between Roman Catholic and Protestant. I myself am convinced that so far as Protestants at any rate are concerned, school accommodation will never be placed on a satisfactory basis in Belfast until the schools are made a charge on the rates.

"The system that has hitherto prevailed has proved to be inequitable and inefficient. It is inequitable because there are thousands of ratepayers in Belfast who have never given a penny towards the schools, so that the burden of providing and maintaining the schools has fallen upon a section of the community, and that often the section least able to bear it.

"As to the inefficiency of the system, that has now passed beyond the region of controversy; in fact, if my knowledge of the resources of Belfast were limited to what I find in connection with the schools I should imagine that we were living in one of the poorest cities in the British Isles. If I were asked, therefore, whether I should be in favour of striking a rate for providing new school buildings and for improving the existing ones, I should say 'yes, on two conditions—first, that there would be no undue interference with the powers of the Roman Catholic managers, and, second, that adequate facilities be afforded to all religious denominations to receive religious instruction in schools provided in whole or in part out of the rates. By adequate facilities I mean such facilities as are afforded in the Belfast Model School.'"

Mr. Kelly adds that he would give power to the ratepayer to allocate his rates to the religious body of his choice.

Without expressing any opinion on this point, we may add that no system of rating for educational purposes can be carried out without new legislation.

It seems to us that meanwhile the people of Belfast might take useful action in the matter. Seeing that the National Board of Education is ready to advance two-thirds of the cost of building and furniture if the schools are

vested in local trustees, and that in the case of vested schools, the local management can be, and in fact is, left to the denomination, a strong Education Committee might he formed for Belfast, to substitute a few good new schools for many old and unsatisfactory ones.

Or it might be possible to form two such Committees, one for the Catholic schools and one for all others. The Committee or Committees would have to raise one-third of the money required.

The evidence given before us constitutes a serious indictment against the sanitary condition of a large number of Belfast schools and demands the careful attention of the citizens.

In visiting, as we did, the homes of the working classes it was impossible not to be struck with the difficulty which the dirty habits of many of the people place in the way of improvement. If it is well nigh impossible to change the rooted habits of grown men and women, at least it should be attempted in the schools to train a new generation in better ways; and this can only be done if the schools themselves are models of scrupulous cleanliness and good sanitary arrangements.

We should like to add that systematic medical inspection of the pupils in the National Schools would be of very great value.

Section XI.

CONDITIONS OF EMPLOYMENT.

As we have already pointed out, Belfast is the home of the flax and linen industry. About 6,000 men and 28,000 women and children are employed in the mills where the flax is prepared and spun, in the sheds where the yarn is woven into fabrics, and in the workshops, where these are worked into finished articles.

Next in importance is the shipbuilding industry, in which about 15,000 men are employed.

There are engineering shops mainly for the production of textile machinery, several important tobacco factories employing men, women, and children, and some large distilleries.

In addition to these a large number of persons are engaged in various branches of the building trades, and in the shops connected with the distribution of food, clothing, and household requirements; but as the conditions attendant on these branches of employment are common to other towns, it is not necessary to make any special reference to them in connection with Belfast.

Neither is there any peculiar feature connected with engineering and shipbuilding works. At Messrs. Harland and Wolff's works we found in the wood working shops an effective scheme of ventilating pipes, connected with the various machines, through which dust is carried off by means of fans. This system of ventilating wood working shops is also in successful operation in many places in England and elsewhere.

Our observations indeed may properly be limited to the various branches of the flax industry, not only because of the large number of persons, mainly women and children, employed therein, but also because the conditions attending certain processes seem likely enough to affect the health of these workers. We may mention the humidity of the wet spinning rooms; the hot and damp atmosphere which is said to be necessary for certain kinds of weaving, and the dust incident to the processes of hackling and carding.

In recent years the conditions have been greatly improved, and notably in the process of hand hackling, which used to be a very unhealthy employment.

In some of the hand hackling rooms which we visited we found a successful arrangement by which the dust produced was at once drawn away by means of fans through a system of metal pipes or wooden conduits. Where effective ventilation of this kind is applied, the dangers connected with this process may be considered to be practically removed; and the workers themselves testified to its efficiency and utility.

Improvements in hackling machines have also been introduced, providing for the automatic reversal of the holders, so that it is possible to confine the working boys to the feeding side of the machines and to direct the ventilation so as to carry the dust incident to the process away from them.

The supervision exercised under the Factory Acts by His Majesty's Inspectors, and the official Regulations as to temperature and humidity, have also done much to mitigate the evil conditions of weaving sheds and wet spinning rooms, while various modifications in spinning frames have been introduced with the object of preventing, as far as possible, the scattering of water and the escape of steam, and, in many cases, the workers are protected by waterproof aprons.

Little progress, however, seems to have been made in reducing the excessive dust to which the feeders are exposed in the process of carding tow. The condition of the carding rooms remains generally unsatisfactory, although, at the factory of Messrs. J. and T. M. Greeves, Limited, we were shown experiments in ventilation, by which fresh air, warmed in cold weather, was delivered over the head of the feeder, and dust was absorbed by means of fans at the back of the cards. The air currents are thus directed away from the feeder, so that considerable improvement was brought about.

But while some employers have spent considerable sums in improving the conditions of ventilation in their factories, there are many mills which are far from reaching the same standard. No doubt there are many difficulties in the way, such as old-fashioned buildings, and the cost of improvements which all employers are not equally able to bear. We were able to satisfy ourselves that His Majesty's Factory Inspectors are fully alive to the importance of striving to raise the ventilating arrangements of all factories, at least to the standard of the best, while, we believe, there is a general willingness, on the part of factory owners, to adopt such improvements as have been shown to be effective and within possible limits of cost.

One of the evils connected with factory life is the unsatisfactory character of the meals which the workers are able to obtain within the time allowed, especially where, as so often happens, the women are themselves workers, and there is no one left at home to prepare the meals. In a great many cases the workers content themselves with tea, bread and butter, because of the facility of preparation. We were surprised to notice, however, that tea was often actually preferred for the mid-day meal, even in those cases where the employers had provided dining-rooms in which more wholesome and nourishing food was available at cost price. At the York-street Spinning Company's Mills excellent dining-rooms were provided of which comparatively few availed themselves. At Messrs. Philip Johnston and Sons', Jennymount Mills, the "half-timers" were supplied with breakfast and dinner free, the firm considering themselves repaid by the better health and consequent better work of the children.

In another part of this report (see Phthisis, page 31) we have discussed the mortality from Phthisis in Belfast, and have referred to the question how far this may be due to the conditions of employment.

Sir John Byers and Professor Lindsay gave evidence on this point, but their data were admittedly fragmentary. In the regrettable absence of reliable and complete data as to the mortality of Belfast, to which we have already called attention, it is impossible to express any definite opinion upon the effect of factory conditions there, but the special incidence of Phthisis upon women at the ages of 25–45 suggests that industrial employment may have operated in increasing the exceptional mortality from Phthisis among females at these ages.

On the other hand, as we have pointed out in the section already referred to, "Belfast's record as regards Phthisis is not exceptional for Ireland, and even shows signs of improvement which that of Ireland as a whole does not."

As regards infantile mortality, Belfast compares favourably with many important English industrial cities, but the employment of married women in factories, which however is not peculiar to Belfast, is undesirable on the ground that it must often involve the neglect of young children. It may be well to point out also that evidence was given before us that child-bearing women in Belfast continue at their employment in the mills as long as it is possible before confinement, and that they return dangerously soon afterwards. We are certainly of opinion that some change in this respect is required in the interest of both mother and child. It would be a great advantage if employers could facilitate the provision of assistance during the forced period of unemployment in such cases by means of organised sick funds or loans repaid by small instalments from wages.

Section XII.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS.

For convenience of reference, we proceed to bring together the conclusions and recommendations to which we have been led; although these will be best understood if they are considered in connection with the full Report.

Population and Vital Statistics.

(1.) We estimate the population of Belfast for 1906, at about 380,000. The official estimate of the Registrar-General for Irelaud (366,220), is in our opinion too low, and that based on the method employed by the Registrar-General for England and Wales (397,292) is too high.

It is desirable that the methods of framing estimates of population for intercensal years by the Registrars-General for the three divisions of the United Kingdom, should be reconsidered with a view to arriving at such reasonable uniformity as may make possible useful comparisons of vital statistics.

(2.) The Corporation of Belfast, like other local authorities in Ireland, are without information as to the details of deaths occurring in their district, beyond the mere numerical particulars obtained from the Registrar-General's official publications.

Such information is of essential importance, for without it a sanitary authority cannot adequately search for or cope with causes of disease and death.

We cannot urge too strongly the importance of this matter. The most effective and natural way of dealing with it, is to follow the precedent of the English and Scottish Registration Acts, even if such a method involves fresh legislation; and we recommend that this should be done.

The proposal to obtain from the Registrar-General for Ireland returns of the deaths ascribed to epidemic diseases and phthisis only, we consider to be inadequate.

(3.) Our examination of a variety of data indicates that the death-rate from all causes in Belfast is, and has been for several years, about the same as that of Manchester, rather lower than that of Dublin or Liverpool, but not so low as that of other large cities of the United Kingdom. Although the death rate of Belfast *from all causes* is by no means low, we think the allegation that it is, or has been in recent years, excessive, cannot be maintained.

(4.) On the other hand, mortality in Belfast from certain causes, notably from enteric fever and from phthisis, and to a less extent, from diseases of the nervous system, has been excessive.

(5.) Although Belfast holds a not unfavourable place among other large cities in regard to infantile mortality, the death-rate among the other young age groups of the population appears to have been excessive in Belfast. The causes operating to produce this relatively high mortality at these young ages should be thoroughly investigated.

(6.) The mean annual mortality from enteric fever has been so exceptional in Belfast for the last 25 years, that it appears to have no parallel in any other city or large town in the United Kingdom.

Insanitary conditions have no doubt played a very important part in fostering enteric fever in Belfast, but cannot of themselves account for so excessive a mortality from this disease, or for other features of its history.

The water supply cannot account for fever in Belfast, because there has been no relation between the distribution of the disease and the distribution of any one of the three separate sources of water supply. On the contrary, the incidence of fever on different parts of the city has been generally similar and simultaneous, irrespective of water supply or insanitary conditions, and moreover it appears to have almost exclusively affected the working class areas of the city.

Neither can the constant excess of enteric fever in Belfast be attributed to the local and occasional outbreaks which have been traced to infected milk.

On the other hand, the known features of the history of Belfast fever are consistent with an explanation attributing them to the influence, direct and indirect, of shellfish gathered from the grossly contaminated foreshores of Belfast Lough.

(7.) No system of sewage treatment, within practicable limits of cost, will fully safeguard the Lough shellfish; and we are of opinion that powers should be obtained to prohibit the gathering of these shellfish for human consumption.

(8.) Mortality referred to phthisis and other tuberculous diseases has been and is excessive in Belfast in comparison with English and Scottish cities, but it has not been exceptional for an Irish city. Since 1895 there has been some diminution of it in Belfast.

The age and sex incidence of phthisis mortality in Belfast and Ireland is very different from what it is in Manchester and in England and Wales. It may to some extent be due to differences in disease nomenclature in the two countries. The whole question of phthisis in Ireland seems to us to require further and exhaustive inquiry.

(9.) We have refrained from any recommendations in regard to the notification of phthisis and the provision of sanatoria or dispensaries, as the Local Government Board for Ireland have advised local authorities in recent circulars, and we understand that a Bill on these subjects is about to be introduced by the Chief Secretary for Ireland.

Water Supply.

The evidence adduced as well as the inspections made by us showed that, although a great improvement has been effected in the Woodburn and Stoneyford catchment areas by the acquisition of all houses and lands within a distance of from half a mile to threequarters of a mile from the reservoirs, there still remain in these catchment areas sources of pollution which make it imperative that the supply from them should receive long storage and most careful filtration.

Having regard to modern investigations and to the necessity admitted by all the expert witnesses for very careful treatment of the Woodburn and Stoneyford waters, steps should be taken as soon as possible to secure uniformity of working of individual filters, as was recommended more than once by Professor Percy Frankland, by whom the Belfast water supply has been analysed quarterly since 1898. His special reports made from time to time contain much valuable information, and it is to be regretted that the advice they contain was not more fully attended to.

In our opinion it is necessary that in future the filtration works should be managed in full accordance with what modern knowledge shows to be required, including—

(*a*) The use of fine sand of a standard size in the upper layers of the filters for a depth of at least 12 inches.

(*b*) The use at all times of as great an area of sand as can be made available.

(*c*) The prevention of unduly rapid filtration by the use of improved regulating apparatus capable of fine adjustment.

(*d*) The bacteriological control of the results of filtration.

The possibility of the passage of unstored water to the filters and of unfiltered water into the filtered water reservoirs or mains should be excluded.

The question whether or not the Water Commissioners should have abandoned the older catchment areas and developed the Mourne Scheme more rapidly than was at first intended has been carefully considered by us. We are satisfied that this Scheme was not intended to he a substitute for the older waterworks, but merely to supplement them, and we are of opinion that the Commissioners have acted not unwisely in their policy in recent years. Evidently their hands were greatly tied by imperative financial considerations, and in deciding to maintain and improve the older waterworks they were guided by expert advice of the highest kind.

The evidence regarding the Woodburn and Stoneyford supplies does not, in our opinion, justify their condemnation, but it establishes the necessity for very careful treatment of those supplies.

The Mourne Mountains catchment area is an upland gathering ground of the highest class. It is uncultivated, and is free from human habitations. The whole area is owned by the Water Commissioners, with the exception of a small portion in the Annalong valley, where some quarries are being worked, a considerable number of men being daily employed there. There can be no doubt that it is important that this small portion of the catchment area, situated as it is not far from the main Annalong river, should be acquired hy the Commissioners, if there is no possibility of diverting the water which flows from it. The early development of the Mourne supply should be the main feature of future policy.

We are of opinion that, although the Water Commissioners have done much excellent work, the water supply of Belfast should be in the hands of the Corporation, and base this opinion on the following grounds :—

(1.) That water supply is essentially a matter which should be administered by the authority responsible for the public health. The experience of Belfast as regards enteric fever furnishes a strong practical reason in favour of this principle. If the Corporation had been fully aware of the distribution of the water, and if the Water Commissioners had been fully aware of the distrihution of the disease—in other words, if there had been one hody instead of two—it is difficult to helieve that serious question could ever have arisen that the water had played a prominent part in the productiou of enteric fever in the city.

For other practical reasons, also, it should be managed by the authority which controls the streets of the city and the erection of buildings, as with such single control there would be a clearer and less divided responsibility as to sanitary conditions, and a more convenient and economical discharge of official duties, than is now possible, could be secured.

(2.) That while the financial powers of the Water Commissioners are strictly limited the Corporation have wider financial resources.

(3.) The multiplicity of elections leads to reduced interest being taken in them, and increases the difficulty of securing the best men for the direction of public affairs.

It is interesting to note that in connection with the inquiry held in 1859 hy a Royal Commission into rating questions at Belfast, the report stated—"We are of opinion that it is desirable that the duty of supplying the town with water and the exercise of the powers necessary for that purpose should be imposed on and entrusted to the Corporation of Belfast" "We recommend that the Water Commissiouers should be consolidated with the Corporation of Belfast."

Main Drainage.

(1.) The relief of the main intercepting sewers at times of heavy rainfall, and the prevention of flooding in certain areas of the city, which have for years been subject to it, should be effectively dealt with as soon as possible.

We are of opinion that the proposal to divert a large part of the storm waters of the Blackstaff river by a tunnel carried from a point near the junction of the Blackstaff river and Clowney Water river to the Lagan is a good one, but in addition we consider the weirs in the Blackstaff river and Pound Burn should be removed, and the channels rectified and improved, so as to be as free and easily maintainable as possible. A good form for such stream beds in a city area is a semicircular channel with smooth slopes of concrete or paving rising from the edges of the channel. By Section 24 of the Belfast Improvement Act, 1847, the Corporation is specially empowered to deal with weirs and other obstructions which are likely to prevent good drainage.

(2.) Special care should be taken to remove grounds for complaint as to surface ventilation of sewers—

(*a*) By systematic flushing of all sewers with flat gradients.

(*b*) By the division by flaps of steep sewers into moderate lengths, separately ventilated.

Sewage Disposal.

We approve of the work now proposed and partly carried out by the Corporation, the object of which is to cut off the discharge of sewers to the streams and to the foreshores, and the concentration of the city sewage to the present main outfall and to an outfall on the south of the city at Sydenham.

We think that in view of the responsibilities undertaken by the Corporation in 1898, it is much to be regretted that the withdrawal of suspended matter from the sewage before discharge has not been carried out long ago, and we urge that this should be now completed without delay.

If this be done, and if the discharge of the clarified sewage be strictly limited to the first 3½ hours of the ebb tide, we think it is at least very doubtful if it will be necessary to further treat the sewage, before discharge, by any process of filtration. A complete process of filtration which would reduce to a negligible quantity, the factors which go to feed the *Ulva*, and deal, as we understand is proposed, also with storm waters, must necessarily be very costly, and would not wholly remove the danger of shellfish contamination.

While such a process, if effectively carried out, would no doubt reduce the *Ulva* growth, it might not be productive of important immediate results, because (1) for some years to come the accumulation of sewage mud on the banks will continue to give off ammonia; (2) sources of impurity will still remain in connection with storm overflows, the dirty flow of streams, and the sewage of the population outside the city.

In any case the carrying out of important works for sewage treatment will necessarily require several years, and in our opinion it will be necessary for the Corporation and the Joint Board to continue to remove the accumulations of *Ulva*.

The removal of decaying weed, which to a certain extent has been carried out on the south shore by the Joint Board during the last two years, has admittedly greatly reduced the nuisance, and as the decaying weed produces matters which go to feed a new generation of weed, there can be no doubt that the removal is of the greatest value.

We believe that this removal could be organised in a more efficient way than at present, and that experiment may lead to the utilization of the weed so as to go a long way towards covering the expense of the removal.

We think it well worth consideration whether it would not be cheaper to remove and utilize the weed accumulations, than to carry the treatment of sewage sufficiently far to remove the matters on which the *Ulva* thrives, and whether the whole problem could not be best solved by the action of a Joint Board representing all the sanitary authorities of districts abutting on the Lough.

We strongly recommend that the slob lands in front of the mouth of the Connswater and within the limits of the city should be reclaimed.

Sanitary Administration.

(1.) As far as possible the Public Health Committee should control all the departments most closely concerned with public health matters.

(2.) The existing organisation of a Medical Superintendent Officer of Health and fourteen District Medical Officers of Health has not worked satisfactorily. We are of opinion that the system is unsuitable and unworkable in the case of a city like Belfast, and that re-organisation should be effected so as to bring the Public Health administration into line with that which obtains in the cities of England and Scotland by making provision for the appointment of a special medical staff for public health work and not dependent on those whose first duty must be to tend the sick

The whole responsibility of the administration would thus be placed on the Medical Officer of Health, who should have such assistance as may be deemed necessary.

A Bacteriologist of experience should be added to his staff, and the Veterinary Surgeon recently appointed should also be placed under the direction of the Medical Officer of Health.

(3.) The number of Sanitary Sub-Officers should be increased, so as to secure systematic and regular inspection of their districts.

(4.) There should be systematic interchange of information with School Managers as to infectious disease.

(5.) The hospital accommodation provided by the Corporation for infectious diseases is inadequate and should be increased, and the Guardians relieved of all responsibility for the treatment of these diseases.

Cases of infectious disease treated at home should be kept under definite supervision until their termination.

The excessive number of cases of simple continued fever should be regularly examined from the point of view of their relationship to enteric fever.

(6.) The Corporation should, as soon as possible, provide an efficient steam disinfecting apparatus in a properly equipped disinfecting station, and should re-organise the methods employed for the disinfection of houses.

(7.) Double tenancy of houses should be prohibited save where suitable water-closet accommodation is provided for each portion of the house let independently.

(8.) Except in suburban houses, all ashpits should be done away with, and ash bins substituted.

(9.) The removal of refuse at least twice a week from small and confined back yards in the more congested areas of the city is, in our opinion, necessary, and removal at least once a week in the less congested areas should be carried out.

(10.) The storage of ashpit refuse at the Stewart-street depot should be discontinued, and that intended for use as manure should at once be sent out of the city.

Additional Destructors should be provided.

The tipping of ashpit refuse upon sites within the city, which may ultimately be built upon, should he discontinued.

The removal of ashpit refuse, and the cleansing of streets should be controlled by one Committee, and by one Superintendent or Inspector.

(11.) Back passages should be frequently and systematically cleansed, and when built on both sides should be paved with smooth material.

(12.) The revision of the Building bye-laws should be pressed forward.

(13.) Certain congested areas with old narrow streets or blind courts should be dealt with as insanitary areas, and cleared. In suitable positions, the sites or parts of them could with advantage be left open as play-grounds for children.

(14.) The codification of the local Acts should be undertaken.

Milk and Meat Supplies.

The Regulations in force under the Dairies, Cowsheds, and Milkshops Order should be more stringently administered than hitherto.

We consider that the present staff is not sufficient for this branch of Public Health administration, and should be augmented.

Strict attention should be given to the question of the conveyance of milk and milk products in clean and properly constructed vehicles, either by rail or road.

More careful supervision should be exercised in future as to the class of shop or premises from which milk is retailed.

Having regard to the supreme importance of a pure milk supply, we are of opinion that fresh legislation is urgently needed, with a view to prevent the distribution of milk which is capable of causing disease in man.

Steps should be taken without delay to provide a more modern and commodious Abattoir.

The existing private slaughter houses in the city should be closed.

Schools.

While, no doubt, something could be done by religious bodies, or groups of them, forming committees of management, and accepting Government assistance on the condition of vesting the schools in Trustees, we are of opinion that no effective progress will be made until the ratepayers are called upon to take their share of the burden of education. .

Meanwhile we can only advise the Corporation to rigorously enforce the powers they have under the Public Health and local Acts, and to require that their own regulations shall be observed in all plans for new schools submitted to them for approval.

Conditions of Employment.

The evidence available on this subject is only fragmentary, and does not warrant the expression of any definite opinion. On the one hand the special incidence of phthisis mortality on women at the ages 25--45, suggests the possible influence of occupation ; but, on the other hand, Belfast's record as regards phthisis mortality at all ages and for both sexes is not exceptional for Ireland, and indeed shows signs of improvement which that of Ireland as a whole does not.

We have the honour to be,

Gentlemen,

Your obedient Servants,

T. WALTER HARDING.
A. K. CHALMERS.
L. W. DARRA MAIR.
P. C. COWAN.
D. EDGAR FLINN.

T. P. NOLAN, *Secretary.*
10*th April*, 1908.

ADDENDUM

TO THE

REPORT OF THE BELFAST HEALTH COMMISSION.

ENTERIC OR TYPHOID FEVER IN BELFAST,

By Dr. L. W. Darra Mair.

It has been shown in our Report (page 17) that during the three years 1900, 1901 and 1902, the death-rate from enteric fever in Belfast (·72 per 1,000) was excessive as compared with Dublin (·34), Manchester (·13), and England and Wales (·15).

This excess of enteric fever in Belfast has not, however, been confined to the three years in question; on the contrary, it has been a striking feature of Belfast vital statistics for very many years.

In order to show how excessive the incidence of this disease has been in Belfast, the following table, which has been prepared from data published in the decennial supplements of the Registrars-General for Ireland, England and Wales, and Scotland, compares the Belfast record with that of other big towns.

Table I.—Showing, for certain Registration Areas comprising large cities as regards particular decennia and for the cities themselves in the five years 1901-1905, mean annual death-rates per 1,000 living from enteric and simple continued fevers:—

—	1881–1890.	1891–1900.	1901–1905.
Belfast, ...	**·50**	**·76**	**·53**
Dublin, ...	·50	·48	·25
Cork, ...	·27	·19	·09
Liverpool, ...	·27	·29	·21
Manchester, ...	·27	·22	·13
Leeds, ...	·32	·20	·15
Sheffield, ...	·22	·28	·15
Bristol, ...	·16	·10	·09
Birmingham, ...	·17	·19	·18
Glasgow (City), . ..	·27	·22	·15

From this table it appears that in the earlier decennium (1881-1890), mortality from fever was practically twice as great in Belfast as in any other of these towns, with the exception of Dublin; that in the later decennium (1891-1900)

this already high mortality from fever increased in Belfast by as much as 50 per cent., while in the other towns, with the exception of Sheffield, perhaps, the rate fell or remained about stationary; and that in the most recent period, the quinquennium 1901–5, Belfast fever mortality, though diminished, was still more than twice as great as that in any of these towns. Moreover, if the records of towns in England and Wales having a population of 50,000 or more be examined, it will be found that in no single case did the mortality from enteric fever during the decennium 1891-1900 approach the high figure of Belfast, the highest rates being found in certain manufacturing towns of Lancashire, Durham, and South Wales, where they ranged from ·40 to ·49 per 1,000.

Excessive mortality from enteric fever in Belfast without parallel in other towns of the United Kingdom.

It thus appears that the mortality from this disease in Belfast has been not only great, but excessively great, and that over series of years no other town of the United Kingdom equals or even approaches it in this respect. There is not occasion for surprise therefore that the public mind in Belfast has been filled with anxiety in respect of this matter, and that desire should have arisen to ascertain why a disease which, by reason of its generally accepted source in human excremental filth, should be easily preventable, has nevertheless prevailed there so severely. Nor is it matter for surprise that the public authorities of Belfast have been reproached—the Corporation for alleged neglect of the sanitation of the city, the Water Commissioners for having possibly supplied impure water—and that a large amount of evidence was tendered on the subject. Also no doubt, it was hoped that the information thus placed before the Health Commission, and the investigations the Commission would be led to make in consequence, might result in some light being thrown on the general problem of the conditions which have specially conduced to this undue maintenance of enteric fever.

Importance of the problem of its causation.

In view of these considerations, and in view also of the manifest importance of the bearing which elucidation of the problem may have on public expenditure in Belfast, it is necessary to treat the matter in detail.

Records of mortality from enteric fever.

The officially published records of mortality from enteric fever in the city of Belfast commence with the year 1881, but those for the Belfast Registration District date back to 1872. It has been explained in our Report that the records of the Registration District are more trustworthy than those of the city, in consequence of the fact that the former are not issued until they have been carefully scrutinised by the Registrar-General, whereas the latter are issued on the responsibility of the local registrars only; and that for this reason, as also because the city boundaries have changed so much, it is necessary to rely mainly on the figures of the Registration District. But in the annexed table, the number of deaths registered in each year from enteric fever and from simple continued fever since the records commenced, is shown for both the Registration District and the City itself, together with the corresponding death-rates, calculated on the assumption that the ratio of increase of population has been uniform from census year to census year (geometrical method).

It may be noted here that although various methods of estimating population are of material importance in considering death-rates from all causes, they make but little actual difference when individual diseases are being dealt with.

TABLE II.—Showing the Annual Number of Deaths registered, with Death-rates per 1,000 living, from Enteric Fever and from Simple Continued Fever in the Belfast Registration District and in the City of Belfast.

	Registration District.		City.	
	Deaths.	Death-rate.	Deaths.	Death-rate.
1872, ..	164	·79	—	—
1873, ..	146	·69	—	—
1874, ..	146	·68	—	—
1875, ..	126	·58	—	—
1876, ..	122	·55	—	—
1877, ..	137	·61	—	—
1878, ..	145	·63	—	—
1879, ..	144	·62	—	—
1880, ..	166	·70	—	—
1881, ..	111	·46	94	·45
1882, ..	124	·51	82	·38
1883, ..	93	·37	81	·37
1884, ..	71	·28	63	·28
1885, ..	72	·28	75	·33
1886, ..	117	·44	121	·52
1887, ..	106	·39	115	·49
1888, ..	109	·40	111	·46
1889, ..	245	·87	241	·98
1890, ..	193	·67	193	·77
1891, ..	158	·54	160	·62
1892, ..	119	·40	134	·51
1893, ..	133	·43	132	·49
1894, ..	169	·54	166	·60
1895, ..	199	·62	213	·74
1896, ..	164	·50	155	·53
1897, ..	402	1·19	370	1·23
1898, ..	664	1·93	662	2·03
1899, ..	286	·81	273	·82
1900, ..	278	·77	269	·78
1901, ..	372	1·00	367	1·04
1902, ..	176	·46	181	·50
1903, ..	151	·39	154	·42
1904, ..	122	·31	119	·32
1905, ..	141	·35	134	·35
1906, ..	104	·25	99	·25

Necessity of including simple continued fever.

The deaths ascribed to "simple continued fever" are included in the above figures, for the reason that there is little room for doubt that in Belfast many of the deaths ascribed to this cause are due to enteric fever. In the weekly mortality returns for Belfast city alone the proportion of such deaths is considerable, though less now than formerly, but in the case of the Registration District the number of such deaths is trifling, one effect no doubt of the Registrar-General's scrutiny.

It will be observed that there are certain discrepancies in the two sets of figures in the table—sometimes, for instance, the number of deaths in the city is greater than that in the Registration District. This again is likely to be due to the absence of the Registrar-General's scrutiny in the former case, although it may also be partly explained by the fact that the city records are for periods of 52 or 53 weeks, while the records of the Registration District are for calendar years.

Mortality from enteric fever excessive in almost every year.

But the figures in spite of these discrepancies tell but one story. They indicate, firstly, that the mortality from enteric fever in Belfast has been excessive, not in one, or two, or three years only, but in almost every year throughout the whole period of 34 years covered by the records. The death-rate was high in the 'seventies,' and though in the early 'eighties' it fell to a comparatively low figure, towards the end of this decennium it increased again and remained at a high level until 1897, during which year and the following four years the mean fever death-rate was higher than ever before. Since 1901 the fever death-rate has fallen considerably, though it cannot be said to have become low, if the experience of other great towns be taken into account, as shown by Table I. Even if the records of the last five years, 1902-6, be compared, so as to leave out of account the exceptional fever mortality of 1901 in Belfast, there is much the same result. During these five years it will be found that the average annual death-rate from fever in Belfast was ·37 per 1,000, as compared with ·18 in Liverpool, ·15 in Manchester and Leeds, ·11 in Sheffield and Birmingham, ·10 in Bristol, ·08 in London, and ·12 in Glasgow during the same five years.

Such, then, is the general history of enteric fever in Belfast, and it is now necessary to discuss the causation of the excess of mortality there from this disease.

It may be said that, broadly, there are three factors which may be thought of as likely to be responsible for excessive amount of enteric fever in a community. They are as follows:—

1. General insanitary conditions;
2. Water supply;
3. Food supply.

Importance of distribution of the disease.

In order to determine whether, in any given prevalence of the disease, one or other of these factors has been at work, either predominantly or partly, it is obviously necessary to ascertain first of all whether the distribution of the disease has or has not coincided with the opportunities for operation of that factor.

For instance, in order to establish a connection between general insanitary conditions and a given prevalence of fever, it is clearly necessary to show in the first place that the areas affected by the fever and the areas presenting, in exceptional degree, general insanitary conditions correspond more or less closely, and the same necessity applies to the case of a suspected water supply or food supply. From these remarks it might appear to be a comparatively simple matter to determine the main cause of excessive prevalence of enteric fever, but, unfortunately, it is frequently far from being so. For example, the exact range and potentiality for harm of general insanitary conditions is difficult to estimate, especially in a great city such as Belfast. Again, water supplies of large cities, and this applies particularly to Belfast, are commonly complex in their arrangements; and as to food supply it is difficult and may be impossible to determine with any precision the range and the limitations in the distribution of particular foodstuffs.

It may, therefore, prove very difficult after all to show with which among the above possible factors, the manifestations of the disease coincide or in the main correspond. But it is at least clear that before any attempt can be made to demonstrate anything of this sort, there must be exact knowledge of the distribution of the disease and of the manner of its incidence—that is to say, knowledge of where it occurred, when it occurred, whether or not it occurred in sudden outbursts, whom it attacked, and so forth.

And this knowledge is necessary not only for the purpose of ascertaining relation between the disease and any particular set of circumstances, but also for another reason. Experience has shown that the manifestations of this disease vary considerably according to the different agencies which have been mainly responsible for its spread, and that much may be gleaned from what may be called the behaviour of the disease, as illustrated by the manner of its incidence, as well as from its distribution, in elucidating the problem of its causation.

Knowledge of the distribution of the disease in Belfast defective.

Full knowledge, therefore, of the foregoing kind is evidently a primary necessity. Unfortunately, however, in Belfast this knowledge is fragmentary except in recent years. It has been explained in our Report how information from the death returns is incomplete. Further, the Infectious Disease (Notification) Act, under the provisions of which knowledge as to the occurrence of *cases* of infectious disease is usually obtainable in detail, was not adopted by the Belfast Corporation until March, 1897, though opportunity to adopt it had continued since the Act was passed in 1889.

As a consequence, detailed information as to sickness from fever, is only available since the early part of 1897, and therefore minute examination of the distribution and behaviour of the disease is only possible since that date. Unfortunately even this information is incomplete in important respects; no record has been kept, for instance, prior to 1907 of the ages of the persons suffering from fever or of the occupations in which these persons were engaged.

Exact knowledge of distribution obtainable since 1897 only.

The Corporation have, however, supplied the number of notifications of enteric fever and of simple continued fever which have been received in every week since the commencement of notification in Belfast, from each of the dispensary or registration districts into which the city is divided; and certain "spot maps," which will be referred to later on, have also been prepared.

This information, incomplete though it be, is very valuable, especially as it so happens that during the period since 1897, Belfast has suffered very severely indeed from fever—particularly in the years 1897, 1898, and 1901, when the death-rate from this disease alone ranged from as much as 1 to about 2 per 1,000 of the population.

Professor Lorrain Smith's reports on the subject of enteric fever in Belfast

It was during the occurrence of the very heavy fever mortality of these years that the Belfast Corporation sought the advice of Professor Lorrain Smith, M.A., M.D., then Professor of Pathology at Queen's College, Belfast, and now Professor of Pathology at Manchester University; and it may be convenient at this stage to refer to the two reports which he submitted on the subject. They were laid before the Commission, and Professor Lorrain Smith himself appeared before them as a witness in support of them.

In both of these reports he formulated the conclusion that in the conditions of the water supply of the city was to be found the "primary cause of the excessive amount of typhoid fever"; in particular in the conditions of the water supplied from the Stoneyford source.

In his first report he based this conclusion on three principal grounds:—

(1.) That cases of typhoid fever had occurred among dwellers on the Stoneyford gathering ground;

(2.) That although the *bacillus typhosus* had not been found in samples of water supplied to consumers in the city, there was present in these samples many varieties of *bacillus coli communis*, a micro-organism which is invariably associated with fœcal matter;

(3.) That a large proportion of these coli micro-organisms was found to give a positive "clumping" reaction with blood-serum derived from sufferers from typhoid fever in the city, in much the same manner as did samples of *B. coli* which had been actually obtained from the organs of such sufferers.

Professor Lorrain Smith's contention on these facts seems to have been that a positive "clumping" reaction of *B. coli* derived from the organs of typhoid fever patients to typhoid fever blood-serum is proof that these micro-organisms were "directly concerned in the infection of the disease"; and that the like reaction of *B. coli* found in the water supplied to the city is proof that they also were "directly concerned in the infection of the disease"; and hence he concluded that water containing these micro-organisms was as matter of fact disseminating the disease, the suggestion being, of course, that the source of the infecting micro-organisms was to be found in the sufferers from typhoid fever on the gathering ground.

It is obvious that this line of reasoning depends entirely on the nature of the deduction that may properly be drawn from the "clumping" reaction given by the *B. coli* and typhoid blood-serum, and it may suffice here to point out that bacteriologists are not agreed on this point. Dr. Houston, for instance, in his evidence, disputed the soundness of Professor Lorrain Smith's deduction (see Appendix).

But apart from this, it is to be noted that Professor Lorrain Smith in this report did not show that the distribution of enteric fever in the city corresponded with the distribution of the water which he supposed to be infected from the particular gathering ground. Indeed, he not only did not do so, but he expressly stated that in his bacteriological examinations of water samples, he had not discriminated between the two sources—Stoneyford and Woodburn—from which the water supply of the city was at that time being derived. From this statement, and from the fact that many of the water samples examined by him were obtained from his own laboratory, which was within the Woodburn area of supply, it would seem, though it is not clearly stated in the report, that his incriminatory *B. coli* were found not only in water derived from Stoneyford, where enteric fever existed, but also in water derived from Woodburn, on the gathering ground of which the disease was supposed not to exist.

In Professor Lorrain Smith's second report there is likewise no serious attempt to ascertain whether any relation existed between the distribution of fever and the distribution of the Stoneyford water. Nevertheless he again declared this water suspect, arriving at this conclusion partly by a process of exclusion of other possible factors of fever. He rejected milk and shellfish, regarding them as not, in the circumstances, possible or probable causes of excessive fever; and further by an important investigation and argument he excluded not only general insanitary conditions from main responsibility for disseminating the disease, but denied also the possibility that the soil of the city in the neighbourhood of dwellings had favoured the growth and persistence of *B. typhosus*. As regards water supply he found confirmation of his first hypothesis regarding the Stoneyford supply in the continued occurrence of solitary cases of enteric fever in dwellings on the Stoneyford gathering ground, and also, it would appear, in the supposition that the majority of enteric fever prevalences in the past, especially in foreign countries, had been caused by polluted drinking water.

Supposition that Stoneyford water was introduced into Belfast in 1888

But also he found confirmation of this hypothesis in another way. The records of fever mortality in Belfast which Professor Lorrain Smith possessed were those of the city alone, dating only from 1881, and he presented a table similar to the second part of Table II., giving the death-rate year by year from enteric fever in the city. From this table he showed, what is quite correct, that there had been a large increase of mortality from this disease in 1889, and further, what was also correct according to his table, that, from that year onwards to 1903, the date of his second report, the death-rate from enteric fever had always remained higher than it had been before 1889. And he endorsed this demonstration with the statement that this increase in the mortality from the disease had been coincident with the introduction of Stoneyford water into the city in 1888, a coincidence which he naturally

regarded as very strong confirmation indeed of his conclusion that Stoneyford water had been the "primary cause of the excessive amount of fever in the city."

Reference, however, to the first part of Table II., in which the death-rates from enteric fever in the Belfast Registration District are given year by year since 1872, will show that, though it be true that there was a large increase of fever mortality in 1889 as compared with the immediately preceding years, it is not also true that the death-rate after that year remained at a higher level than it had been before that year. The table indicates, indeed, that it is not the rise of fever mortality which began in 1889 that is striking, so much as the diminution of this mortality which occurred in the preceding six or seven years.

Stoneyford water not introduced until 1890.

But there is yet graver objection to the foregoing argument of Professor Lorrain Smith. It has turned out that he was misled in his assumption that the water from Stoneyford came into use in the city in the year 1888. Evidence submitted by the Water Commissioners established the important fact that the water from Stoneyford was not delivered at all to consumers in the city until the early months of 1890; that it was then only delivered in small amounts; and that not until the middle of that year was it fully used. It may be added that this fact was publicly announced, by the Chairman of the Water Commissioners, at a meeting of that body, and was reported in the local press immediately after the appearance of Professor Lorrain Smith's report in 1903.

It is clear, therefore, that the confirmation based by Professor Lorrain Smith on the date of introduction of the Stoneyford water into Belfast breaks down.

Severity of fever in Belfast suggestive of causation by water service.

Nevertheless, the hypothesis that the water supply of the city may have been largely responsible for fever cannot be dismissed in consequence. The very severity of the incidence of the disease in Belfast is in itself enough to arouse grave suspicion that the water supply was actually at fault. When as many as two in every 1,000 of a great population die of enteric fever in the space of a single year, as was the case in Belfast in 1898, it cannot fail to give rise to the view that the most likely cause lies in the water supply.

It is inevitable, indeed, that inquiry into the causation of Belfast fever should, in the circumstances, be approached with a bias, so to speak, against Belfast water—in other words, that it should be approached with an expectation of finding the facts fit in with a theory of water dissemination, rather than with a disposition to reject such a hypothesis simply because at first sight the facts do not appear to fit in. Such expectation is necessarily enhanced by the fact that enteric fever has occurred from time to time among the population resident on one at least of the gathering grounds.

It is clearly necessary, therefore, to inquire closely into the available evidence for and against the water, but before doing so it may be convenient to consider the responsibility for the fever of insanitary conditions of general sort—by which is meant the responsibility of defective housing, defective sewering and draining, defective refuse and excrement disposal, and the like.

INSANITARY CONDITIONS IN RELATION TO FEVER IN BELFAST.

Severity of fever in Belfast too great to suggest causation mainly by insanitary conditions.

In connection with this it must be confessed at the outset that just as the very heavy incidence of fever is *à priori* suggestive of water causation, so is it *à priori* opposed to causation by general insanitary conditions; and this for the reason that in no case do the occurrences of enteric fever recorded in other towns of large or moderately large size in the whole of the United Kingdom approach in severity those of Belfast in the last decennium or probably even in the last fifteen years.

If in Belfast insanitary conditions of general sort have been mainly responsible for this unparalleled excess of fever, it should appear that in Belfast these conditions are of a much worse description than they are in other towns, or, possibly, that their potentiality for fostering fever is much greater. There is no valid reason for falling back on the latter alternative; and as to the former, although, as is shown in our Report, there have been and still are many serious sanitary shortcomings in Belfast, and the system of scavenging of privies and ashpits even now is exceedingly defective, it cannot be contended that in a sanitary sense Belfast is on an altogether lower plane than other cities and towns in the United Kingdom. In fact, there can be no doubt that in some respects the evidence points the other way.

For instance, Belfast is, as is shown in our Report, a town of rapid modern development—that is to say, it is a new town—consisting largely of wide streets lined by rows of comparatively modern dwellings, the vast majority of which are self-contained, so that there is an almost complete absence of antiquated courts, alleys, and common yards such as may be seen in Dublin and Cork, and also in many of the older seaport towns in England and Wales. "Slums"—to use the word in this sense—are rare in Belfast Likewise, overcrowding of persons in houses in Belfast may be said to be almost negligible in amount, judging from the last census returns. Indeed much evidence was tendered to the Commission which went to show that in the matter of housing, both in respect of room accommodation and in respect of the scale of charges for rent, Belfast is greatly favoured in comparison with other towns.

Improvement of insanitary conditions coincident with increase of enteric fever in Belfast.

Moreover, it can be shown that for many years improvement of "insanitary" conditions in Belfast, coincided not with reduction but with an increase in the amount of fever. Professor Lorrain Smith showed this in his second report. Thus, he recounts how in the years from 1870 onwards the sanitary conditions and the sanitary administration of the city were improved in various ways. For instance, the scavenging of privies and ashpits was undertaken free of charge by the Corporation in 1892; an immense main drainage system was carried out between 1889 and 1895, involving the removal of practically all sewage hitherto discharged into the River Lagan in its course through the centre of the city; more care was exercised in the construction of house drains; the keeping of pigs in back yards was largely put an end to; since 1880, privies, which were then almost universal in relation with working class houses, had been gradually replaced by water-closets, so that in 1899, when special powers were obtained to expedite this conversion, only about one-third of the total houses remained still provided with privies; extensive clearances of insanitary dwellings had been made; and so forth.

Professor Lorrain Smith then shows that during these years there was a decline not only in the general death-rate but also in the "zymotic" death-rate, from which he makes the deduction that the reforms so effected had been not without success in improving the health of Belfast.

And lastly, he shows that notwithstanding these sanitary improvements and the associated improvement of the general health, mortality from enteric fever in Belfast not only did not diminish but that it actually increased.

There can be no question of this latter proposition as may be seen from the following table :—

TABLE III.—Showing mean annual death-rates from All Causes, from Enteric and Simple Continued Fevers, and from the Principal Zymotic Diseases, in the Belfast Registration District, during certain periods of years.

Period	Fever.	Zymotic Diseases.	All Causes.
Four years—1872–1875, ..	·70	5·0	25·0
Quinquennia—			
1875–1880, ...	·64	3·7	24·5
1881–1885, ...	·40	3·7	25·0
1886–1890, ...	·60	3·4	25·1
1891–1895, ...	·50	3·4	24·0
1896–1900, ...	·97	3·3	21·6
1901–1905, ...	·50	2·6	20·3
Nine years, 1872–1880, ..	·67	4·3	24·8
Decennia—			
1881–1890, ...	·50	3·6	25·0
1891–1900, ...	·76	3·4	22·8

These facts clearly point to the inference that the influence of insanitary conditions cannot satisfactorily explain the general manifestations of Belfast fever, and that whatever share they had in fostering it some other factor in addition must have been in operation. To put it in Professor Lorrain Smith's own words, the facts indicate that there has been a "cause of typhoid at work which has not been affected by these sanitary reforms."

General facts relating to fever in Belfast not explained by influence of insanitary conditions.

Study of the distribution of the disease confirms this inference. Professor Lorrain Smith dealt with this aspect of the matter in his second report in connection with sanitary conditions. The method he adopted was to make a detailed examination of five selected areas in the city which were "chosen with a view of ascertaining the sanitary conditions existing in situations differing from each other as widely as possible."

Facts relating to distribution of fever in Belfast point to same conclusion.

Thus, the elevations of the selected areas ranged from 3 feet to 160 feet; in some the streets were wide and in others narrow; in some the houses were very old and without back passages, while in others the houses were quite modern; the proportion of houses provided with privies ranged from as low as 7 per cent. to as high as 61 per cent.; the condition of the drains and sewers in the areas also varied widely; and lastly, a special feature of one of the areas was that it had been built "entirely on made-up ground, filled in with road scrapings, ashpit and town refuse."

Professor Lorrain Smith then proceeded to show, from the evidence of the incidence of enteric fever on these areas during the years 1900, 1901, and 1902, that there was no discoverable relationship between these several sanitary conditions and the fever witnessed in these areas. For instance, he found that the area built on made-up ground suffered, if anything, less than the average of the city; that the area which examination showed to be the worst of all from a sanitary point of view—with narrow streets, the largest proportion of privies, few back streets or passages, and one of the worst as regards sewers and house drains—had less fever than other areas better favoured in these respects; and so forth.

Cases of simple continued fever, however, were not taken into account in making these observations, an omission which, as will appear later, may have accentuated some of the apparent vagaries of fever incidence noted in these areas. Also, it was not explained that some of these vagaries

may have been in part explicable by variations in the degrees of susceptibility of the populations of these areas, due to differences in their age-constitution. The last census returns showed, indeed, that the fourteen registration districts of Belfast differed widely in this respect. It is probable, therefore, that the selected areas also differed widely, and that the effect of these differences may have had important bearing in regard to the liability of the populations concerned to attack by enteric fever.

Nevertheless, it is clear that there were striking differences in the amount of fever in these areas, and that in those which were relatively sanitary, as well as in those which were relatively insanitary, there was an excessive incidence of the disease. There seems to be little doubt, therefore, of the substantial accuracy of Professor Lorrain Smith's conclusion, from his investigation of these areas, that though such sanitary defects as were found in these areas might all contribute to excess of fever, "there is no evidence to show that the peculiar burden of typhoid which is laid upon the city is due in the first instance to these defects."

Great reduction of privies in Belfast since 1899.

There is, however, another aspect of this matter which has become prominent since the date of Professor Lorrain Smith's last report. In the last five or six years there has been a marked diminution of fever in Belfast, and, likewise, there has been a great reduction in the number of privies in the city. The Corporation obtained powers, in the Belfast Corporation Act, 1899, to compel owners to convert privies into water closets, and although prior to this date many privies had been so converted, it was only subsequent to that date that progress in this great reform became at all rapid. Thus, in 1897 the number of houses with privies was 26,620 in a total of 67,479 houses, and in 1902 the number was reduced to 10,000 in a total of 77,788 houses, while at the present time it is said that the number of privies still remaining in the city does not much exceed 2,000.

No doubt if these two facts, viz., the reduction of privies and the coincident reduction of fever, stood alone, it might be a fair inference that they were connected as cause and effect, and that in the existence of these privies was to be found the main cause of the excessive fever which formerly prevailed; an inference, moreover, which seems at first sight to get support from comparison of the "spot maps," to be referred to presently, with maps showing the extent to which conversion of privies into water closets has been carried.

But these two facts do not stand alone. Close examination of the maps referred to reveal that there are many exceptions to the association of fever with privies. A notable exception was related in Professor Lorrain Smith's second report, and other notable exceptions are to be found in the neigbbourhood known as Ballymacarrett and elsewhere. The Health Commission received considerable evidence also to the effect that fever frequently prevailed in areas in which privies and indeed other gross insanitary circumstances were absent.

Moreover, Belfast is not the only community which has had, or even has now, a large proportion of its houses provided with privies; yet, as already shown, it is the only town in the United Kingdom which has suffered, in recent times, from such large excess of enteric fever year after year. And, as has also been shown, the mortality from this disease actually increased by 50 per cent. in the last decennium (1891-1900), although sanitary improvements, including better scavenging and the conversion of privies, had been effected, which this mortality had been at almost the lowest level ever recorded in Belfast during the preceding decennium (1881-1890), before many of these improvements had been commenced. Furthermore, notwithstanding the immense progress which has been made since 1899 in reducing the number of privies, fever mortality in Belfast, though much reduced since 1901, has nevertheless persisted in remaining much higher than in cities of similar size (see Table, I.). It will also be shown later on that the distribution of this fever in recent years has continued to resemble closely its distribution during the years when it was more abundant.

It is obvious, therefore, that a conclusion which involves explanation for the diminution of fever in the eighties, for the increase of fever during the decennium 1891-1900, and likewise for the diminution of fever during the last five or six years by the effect of insanitary conditions in general, and by privies in particular, is not consistent with the facts.

Conclusion that reduction of fever since 1901 is due to reduction of privies not consistent with the facts.

The evidence as a whole strongly points to the operation of some additional fever agency in explanation of the experience of the decennium 1891-1900, particularly of its latter half, and not least that of the year 1901, by which time a considerable reduction of the number of privies had been effected. Consequently the real question becomes; what of such extra or additional fever agency in recent years? Has it, for instance, remained in operation, as before, so that, notwithstanding the enormous reduction of privies amounting now relatively to their abolition almost, it is still capable of causing fever to remain excessive in Belfast? Or, has the diminution of fever, which has taken place since 1901, been due in the main to a diminished potency of that extra agency, and has the association of that reduction of fever with reduction of privies been merely accidental or, at most, secondary?

Operation of additional factor required to explain the facts.

WATER SUPPLY.

It will now be convenient to discuss the matter in relation to the water supply of the city, and to consider whether the agency of fever may be found there.

In this connection, perhaps the most important consideration at the outset is the characteristic "behaviour" of enteric fever when disseminated by public water service. There can be no doubt that the commonest features of a prevalence of fever due to contamination of a public water supply at its source are the suddenness with which it appears, its wide diffusion within the limits of the supply, and the rapidity with which it attains its acme. Indeed, so abrupt is this onset, and so rapid is the rate at which the amount of fever in the community affected increases to its maximum, and so large is that amount, that such a manifestation has often been termed an "explosion" of enteric fever. This explosive feature was well exemplified in the three largest town epidemics of this disease of recent years in which the evidence of a water causation was very strong, viz., in those which occurred at Worthing, Maidstone, and Lincoln.

Behaviour of enteric fever when disseminated by public water supply.

It is useful therefore to ascertain whether the behaviour of fever in Belfast has resembled in any way the behaviour of enteric fever in these places. This can be done by examining the notification records of the three outbreaks in question, as set forth in the official reports* concerning them, and comparing them with the Belfast notification records supplied by the Corporation. Such examination serves to show that Belfast, in the period covered by the latter records, has not suffered from any such "explosion" of fever as occurred at Worthing, Maidstone, and Lincoln. The annexed Diagram I. indicates this in graphic form very clearly as regards Belfast's worst years of fever. It has been prepared by calculating, from the notification records referred to, the attack-rate from enteric fever per 10,000 of the population in each week of the outbreaks in question, and the attack-rate from fever per 10,000 in Belfast in each week of the years 1897, 1898 and 1901.

Comparison of Belfast with Worthing, Maidstone, and Lincoln.

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* Dr. Theodore Thomson's Report to the Local Government Board on an Epidemic of Enteric Fever in the Borough of Worthing, and in the villages of Broadwater and West Tarring, 1894 [No. 78].

Borough of Maidstone. Report to the Local Government Board on the Epidemic of Typhoid Fever, 1897.

Dr. R J. Reece's Report to the Local Government Board on the Epidemic of Enteric Fever in the City of Lincoln, 1904-5 [No. 226.

But although Belfast as a whole is thus shown not to have suffered from any definite "explosion" of fever, it does not necessarily follow that certain parts of the city did not do so, an important consideration in view of the fact that there is more than one water supply. Diagram II. has been prepared, therefore, to show the weekly attack-rates from fever per 10,000 in four of the registration districts of the city which were the most heavily affected in the three worst years. One of these districts is entirely within the area of the Stoneyford water supply, and the others are entirely, or almost entirely, within that of the Woodburn supply.

No evidence of explosive outbursts of fever in Belfast.

These diagrams show that neither in Belfast as a whole, nor in parts of Belfast situated within different areas of water supply, has enteric fever in these worst years behaved in the "explosive" manner which was a characteristic feature of its behaviour in Worthing, Maidstone, and Lincoln, and which is one of the commonest features of "water outbreaks" of this disease. In years other than these worst years the difference between the behaviour of fever in Belfast and in its sub-districts and its behaviour in these three places was even more striking.

The question arises, however, whether prior to 1897, that is, before the Belfast notification records commenced, the behaviour of fever in this city may not have partaken of the nature of an explosive outbreak. The only available sources of information on this point are the Registrar-General's periodical mortality returns, and these have been examined carefully—both the weekly returns relating to the city, and the quarterly returns relating to the registration district. It is perhaps unnecessary to state in detail the results of this examination; it should be enough to say that careful scrutiny of these records has failed to reveal evidence that Belfast as a whole, or any one of its sub-divisions, has suffered on any occasion from an "explosion" of fever such as the diagram indicates to have occurred in Worthing, Maidstone, and Lincoln.

It cannot be doubted that this evidence as to non-explosive behaviour of fever in Belfast tends to weaken suspicion that in the sources of the water supply is to be found the main cause of that fever, even in the years of 1897, 1898, and 1901, when it was especially abundant.

Nevertheless, this evidence cannot be regarded as conclusive in negation of such causation. The Water Commissioners appeared to be of the opinion, as expressed in their Counsel's final representations, that so long as fever in Belfast behaved in an "endemic" manner, without evidence of explosive outbreaks, it could not concern them, and that in such circumstances it was unnecessary to discuss whether the water supply was responsible.

There does not, however, appear to be sufficient warrant for this contention. There seems to be no substantial reason why, under certain conditions, a public water supply should not be capable of leading to prolonged and repeated prevalences of fever, each of them small in amount, instead of sudden and brief outbreaks of startling magnitude. It has only to be assumed that in the former case the amount of infective material reaching the water is small, and that it has been finding its way there more or less continuously over a long period, to infer that such an outcome is by no means impossible. In fact, the conditions described in Professor Lorrain Smith's reports as having existed on the Stoneyford gathering ground, namely, the occurrence of solitary cases of fever among the inhabitants over a period of several years, often not more than one case occurring in a year, sometimes as many as seven, seem to be the sort of conditions that might be thought of as competent to lead to slight but more or less sustained infection of the water supply.

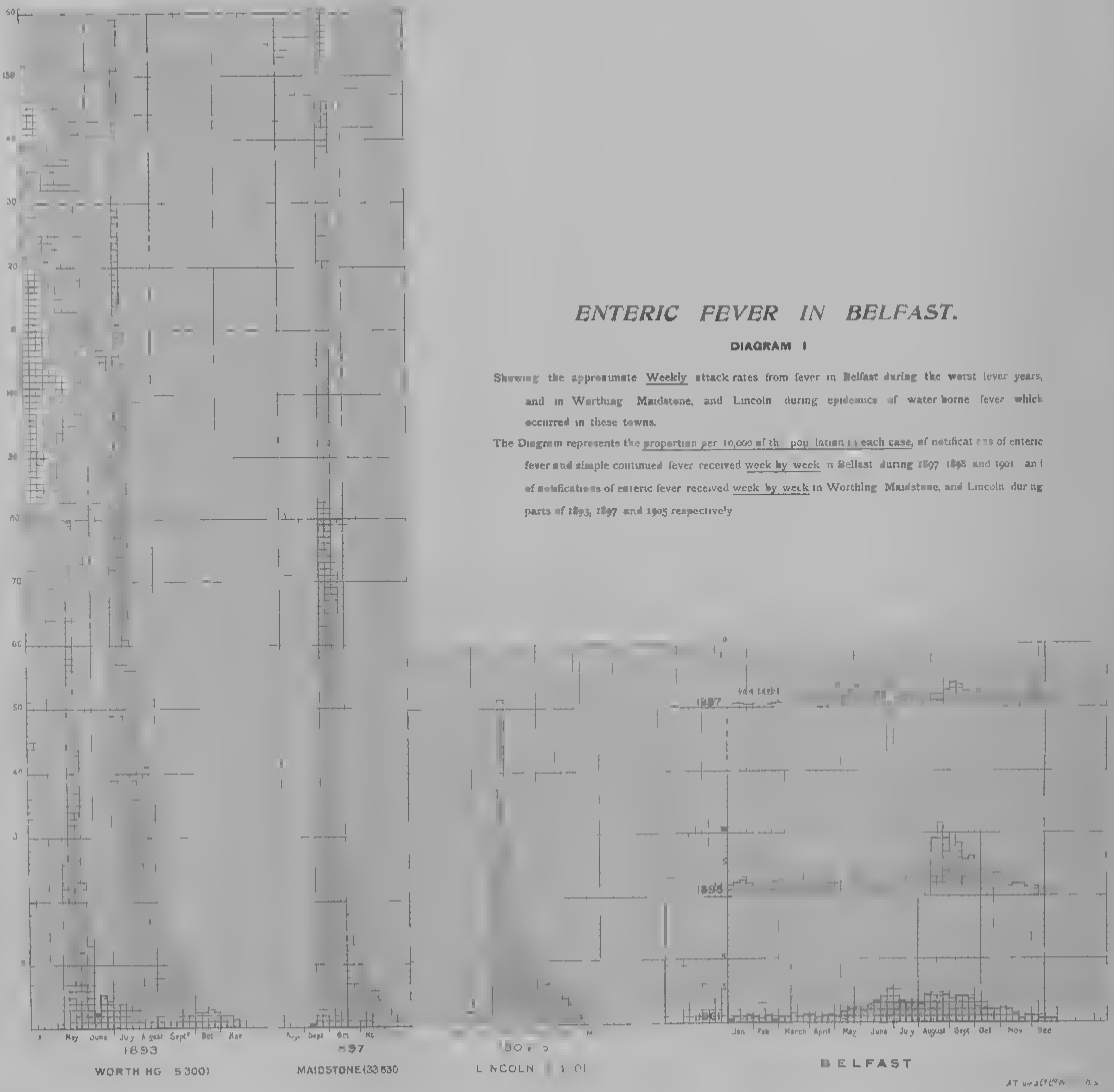
But, however this may be, it is undoubted that, whether the behaviour of the disease be "explosive" or whether it be "endemic," the issue for or against the water supply must rest mainly on whether or not there has been correlation between distribution of the disease and distribution of the water. It is obvious that, in either case, a given water cannot be held accountable for fever among those by whom it is not consumed.

ENTERIC FEVER IN BELFAST.

DIAGRAM 1

Shewing the approximate Weekly attack rates from fever in Belfast during the worst fever years, and in Worthing Maidstone, and Lincoln during epidemics of water borne fever which occurred in these towns.

The Diagram represents the proportion per 10,000 of the population in each case, of notifications of enteric fever and simple continued fever received week by week in Belfast during 1897 1898 and 1901 and of notifications of enteric fever received week by week in Worthing Maidstone, and Lincoln during parts of 1893, 1897 and 1905 respectively



ENTERIC FEVER IN BELFAST,

DIAGRAM II.

Woodburn Water Supply
Stoneyford do do

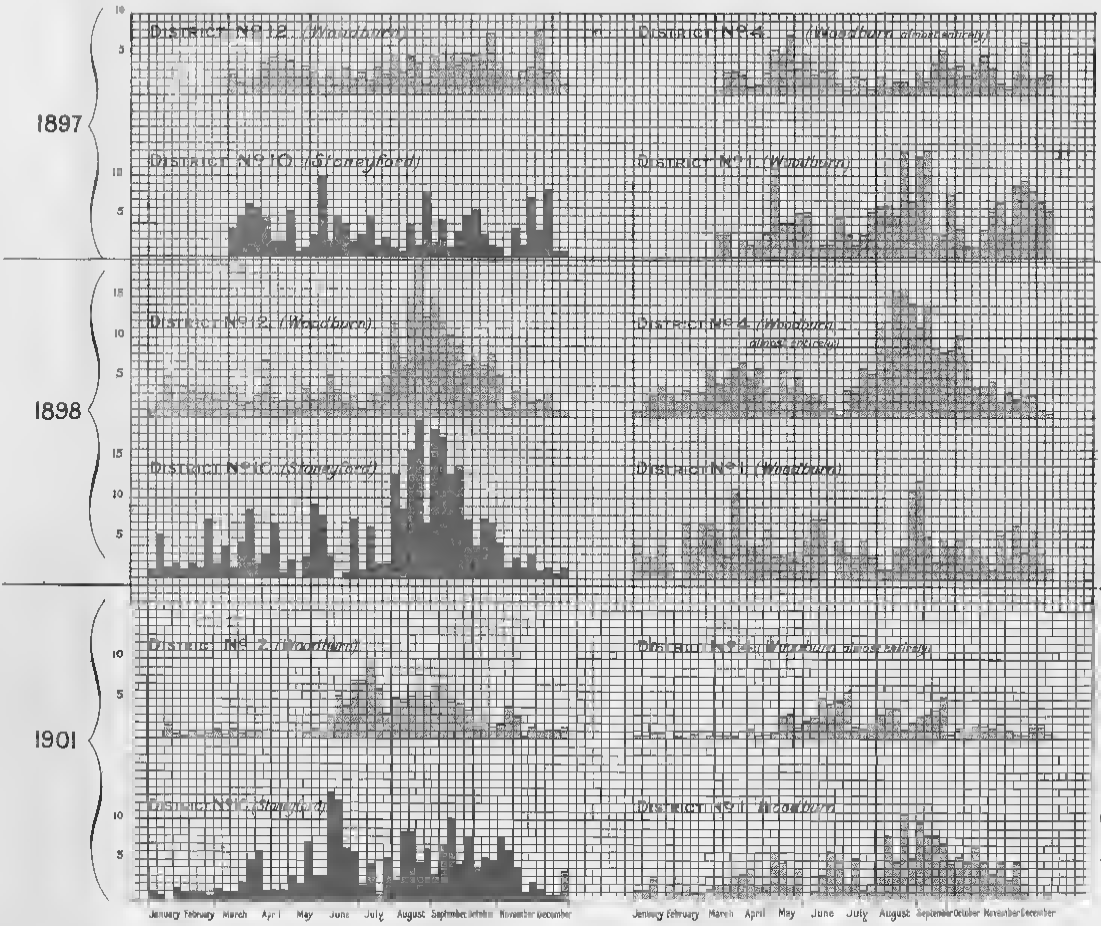


DIAGRAM II.—Showing the approximate Weekly attack-rates from fever in the Registration Districts in Belfast which were most affected in the worst fever years, as represented by the proportion, per 10,000 of the population in each case, of notifications of enteric fever and simple continued fever received week by week, during 1897, 1898, and 1901.

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Distribution of Water in Belfast.

Distribution of water in Belfast.

It so happens that the distribution of water in Belfast is and for several years has been somewhat complex. A description of it appears on pp. 40 and 41 of our Report, but it is desirable to set out here those details which are of importance in the present connection.

For twenty years prior to 1890, Belfast was supplied with water entirely from Woodburn, with the exception of an area of insignificant size and population, supplied from local (Whitewell) springs. It follows from this that if fever in Belfast prior to 1890 was disseminated by the public water supply, it must have been disseminated by this Woodburn supply.

During the first half of 1890, water from Stoneyford was introduced into the city. Its introduction was due not only to the fact that the needs of the increasing population were outgrowing the capacity of the Woodburn supply, but also because there was difficulty in supplying the latter to the higher portions of the city which were at that time being rapidly built upon.

Stoneyford water supplied to two areas east and west of Belfast.

This Stoneyford water thus came to be used for two widely separated portions of the city—an elevated area in County Down to the east, and an elevated area in County Antrim to the west of the city; while the Woodburn water continued to supply the portion of the city lying between these two areas.

Ten years prior to this, however, the difficulty of supplying the higher areas on the west of the city had been met by the construction of a small high service reservoir at Ballyagbagan. This had been supplied at first with water from the Whitewell springs, but for six years prior to 1890 it had been supplied by pumping Woodburn water into it. Soon after the introduction of the Stoneyford water, *i.e.*, in September, 1890, the latter arrangement ceased and the pumping plant was dismantled, but the reservoir itself continued in use, supplied thereafter by gravitation with water from Stoneyford.

The areas of the city served by these two supplies—Woodburn and Stoneyford—as they existed up to the summer of 1900, are shown on the first of the two "spot maps" reproduced.

Ligoniel.

In August, 1900, a further modification took effect by which a high area to the extreme north-west of the city, known as Ligoniel, which is too elevated to be served from Stoneyford by gravitation, came to be a detached portion of the Woodburn area of supply. This was rendered possible by the construction of a new pumping station near the Woodburn service reservoirs, and of a new small high service reservoir near a place called Ballysillan. The water mains laid for this new service at Ligoniel are not connected with those of the remainder of the city. Prior to this introduction of Woodburn water, Ligoniel had been dependent for its supply on local wells.

Introduction of Mourne Mountains water in 1901.

Lastly, in September, 1901, another very important departure was made, namely, the introduction of water derived from the Mourne Mountains. This water displaced the Stoneyford water from the area to the east of the city in County Down, and since that date, this old Stoneyford eastern area has become, with but little alteration, the permanent Mourne water area; but Mourne water is also allowed, when it is plentiful enough, to pass into the Woodburn mains, so that on frequent occasions the Woodburn area of supply proper has been receiving, since the end of 1901, as much as 50 per cent. of Mourne water more or less intimately mixed in the mains with Woodburn water.

The various areas of water supply in the city, as they have existed since 1901, are shown on the third "spot map." It will be seen from this that now the

Stoneyford water supplies the area to the west of the city, the Mourne water that to the east, while the Woodburn water (mixed at times with Mourne water) supplies the intervening area, and also, but in this case unmixed with Mourne water, the detached area of Ligoniel on the north-west.

The populations of these areas of water supply have been estimated by the Water Commissioners to be as follows :—

Stoneyford Area, ...	93,000
Mourne Area, ...	37,000
Woodburn Area, ...	258,000

Distribution of Enteric Fever in Belfast.

Spot maps showing distribution of enteric fever

One of the best ways of delineating the distribution of a disease in a community is by means of "spot maps"; maps, that is, on which are marked by means of dots, the situation of the dwellings in which cases of the disease are known to have occurred. Several maps of this sort showing the distribution of enteric fever have been prepared by the Belfast Corporation, at a cost, it is to be feared, of very considerable labour, for nothing of the sort had been previously attempted. The value of them for the present purpose, however, can hardly be over-estimated. Four maps for 1898, the worst fever year, have been prepared, one for each quarter, as well as separate maps for each of the years 1901, 1903, 1904, 1905, and 1906.

Three of these "spot maps" are reproduced, namely, those for the first and third quarters of 1898, and that for the year 1904. On these maps are also marked the areas of distribution of different sections of the water supply, as well as the boundaries of the various dispensary or registration districts into which the city is divided. It should be explained that the spots on the 1898 maps indicate the location of houses invaded with enteric fever, multiple cases in houses not being shown; while those on the 1904 map indicate the latter also. In all three maps cases notified as enteric fever only are spotted, and cases notified as "simple continued fever" are not included.*

Distribution of fever in Belfast similar year by year,

Scrutiny of these maps will show that in both 1898 and 1904 the distribution of enteric fever was very widespread, and that although the disease was clearly much more abundant in 1898, its distribution in the two years was generally identical. These two features stand out prominently, not only in the "spot maps" reproduced of these two years, but also in all the "spot maps" which have been prepared for the Commission.

Enteric fever not restricted to one or other of the water areas.

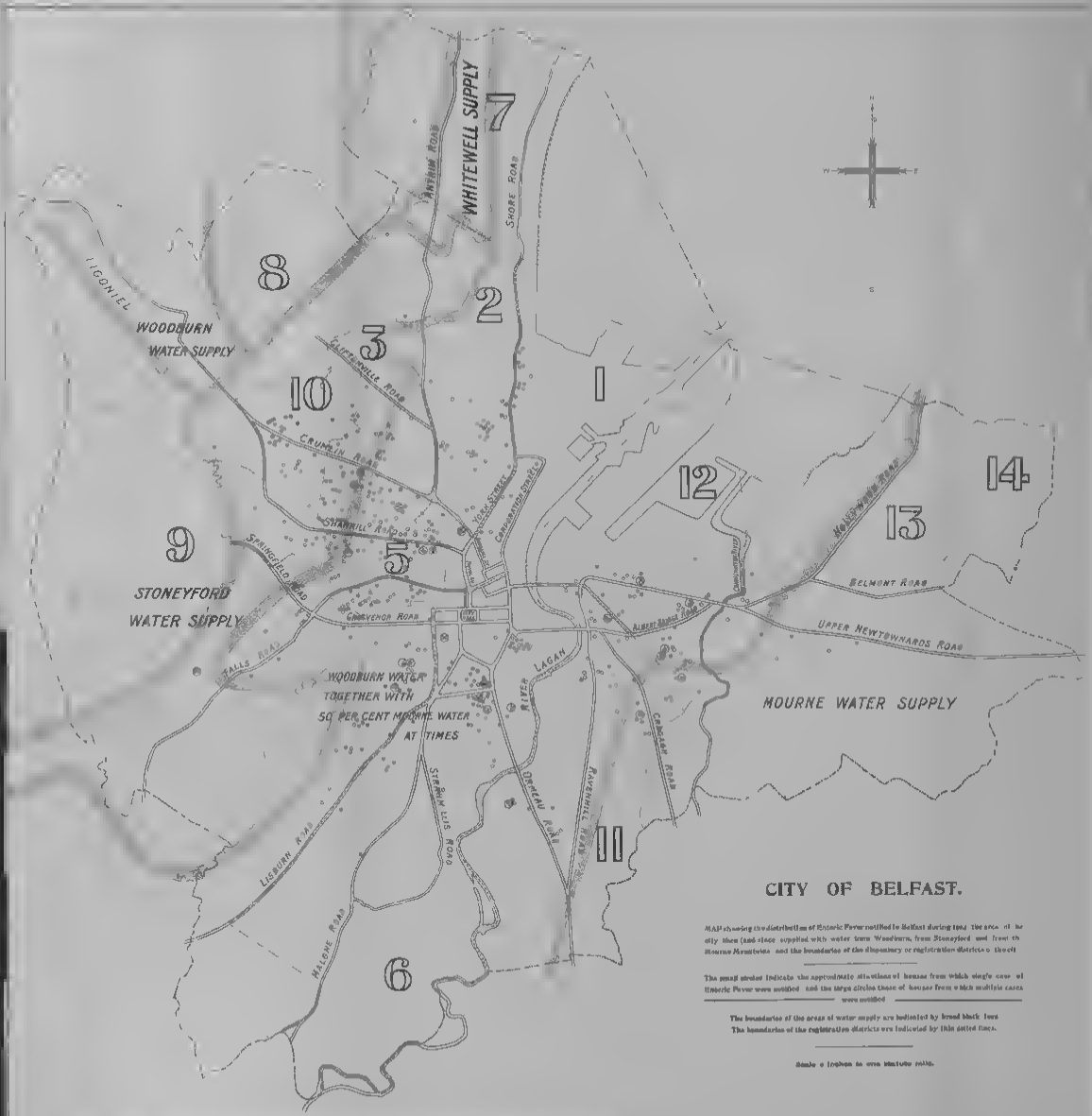
Further scrutiny of the maps reproduced will also show that the distribution of enteric fever is not restricted to one or other of the water areas marked on the maps; rather that the disease appears to have been distributed among them without any sort of relation to their boundaries. This likewise is a marked feature of all the "spot maps" other than those reproduced.

It is manifestly desirable to check the inferences indicated by these "spot maps" by statistical data, but although the populations of the different water areas have been estimated by the Water Commissioners, there is no trustworthy record of the number of cases of fever notified from or the number of houses invaded in each of these areas.

Approximate attack-rates from fever in different sub-districts of the city.

If, on the other hand, attempt be made to ascertain the fever attack-rates for each registration district year by year, two difficulties arise, namely, that the water areas do not correspond with the registration districts; and that, as has been explained in our Report, the popu-

* A map on which cases so notified in 1898, the worst year, have been "spotted" indicates that the distribution of these cases resembled closely that of cases of enteric fever.



CITY OF BELFAST.

MAP showing the distribution of Enteric Fever notified to Belfast during 1904. The area of the city then (and since) supplied with water from Woodburn, from Stoneyford and from the Mourne Mountains, and the boundaries of the dispensary or registration districts are shown.

The small circles indicate the approximate situations of houses from which single cases of Enteric Fever were notified, and the large circles those of houses from which multiple cases were notified.

The boundaries of the areas of water supply are indicated by broad black lines.
The boundaries of the registration districts are indicated by thin dotted lines.

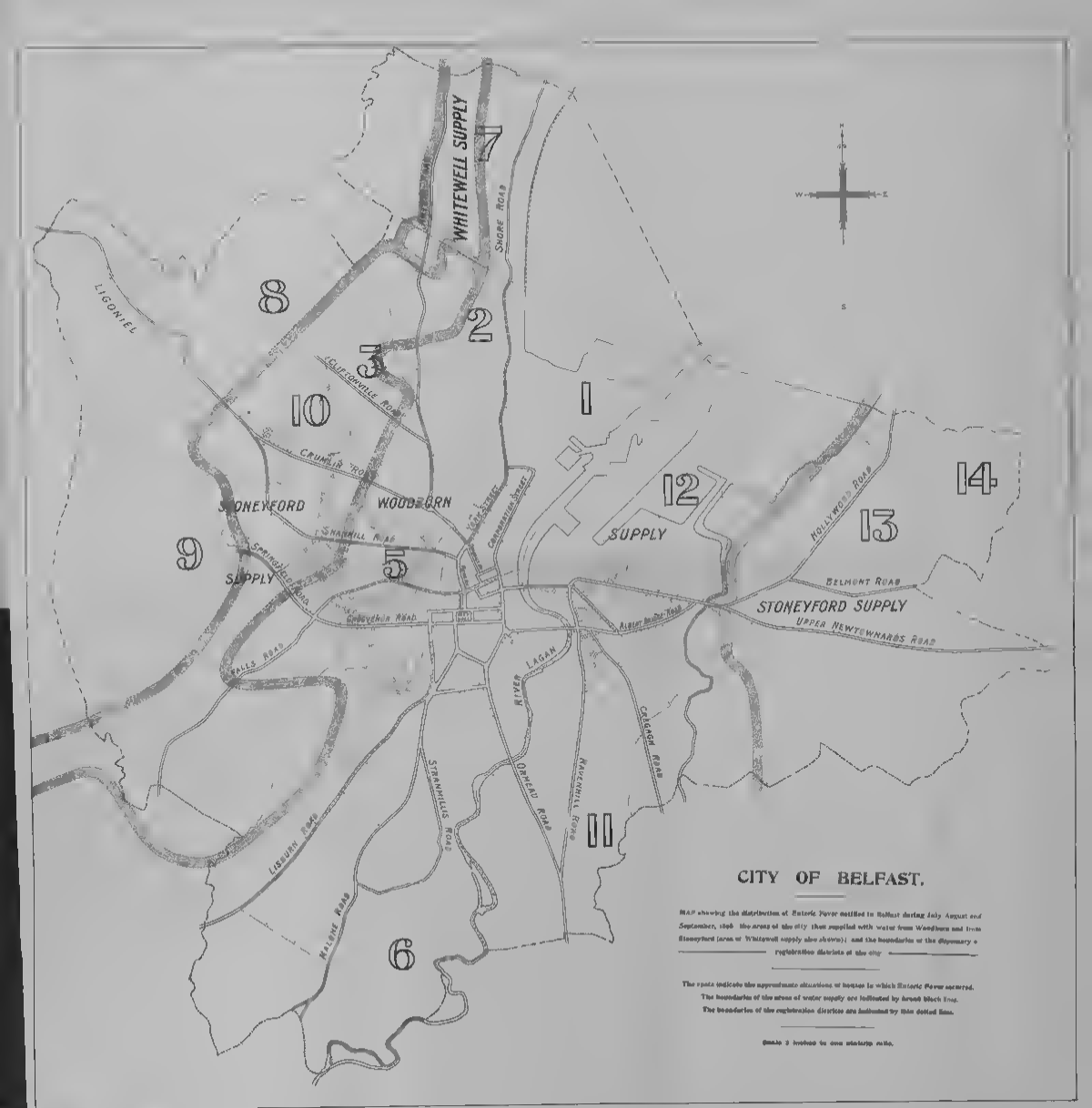
Scale 2 inches to one statute mile.

CITY OF BELFAST.

Map showing the distribution of Enteric Fever as notified in Belfast during January, February and March 1898 the areas of the city then supplied with water from Woodburn and from Stoneyford area of Whitewell supply also shows and the boundaries of the sub-districts or registrar's districts of the city

The dots indicate the approximate situations of houses in which Enteric Fever occurred.
The boundaries of the areas of water supply are indicated by broad black lines.
The boundaries of the registrar's districts are indicated by thin dotted lines.

Scale 3 inches to one statute mile.



lations of these districts are so difficult to estimate that the Registrar-General has abandoned the attempt. Nevertheless, since it is eminently desirable to obtain at least an approximate idea of these fever attack-rates, they have been calculated on the assumption that the populations of the registration districts throughout the period (1897-1906) covered by the notifications, have been the same as the 1901 census showed them to be. It is to he noted that this assumption is not so unlikely as at first it might appear to be, for it has been shown in our Report that it is since 1898 that the population of the city has remained relatively stationary.

TABLE IV.—Showing the number of *notifications* of Enteric Fever and of Simple Continued Fever received in each of the years 1897-1906 from each Registration District in Belfast, together with the population of each District at the 1901 Census, exclusive of certain Institutions :—

District.	Population, 1901.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Enteric Fever.	Simple Continued Fever.	Total
1	14,734, ..	299	334	197	200	276	116	100	62	81	50	662	1,053	1,715
2	46,743,* ..	534	595	297	415	636	214	176	147	202	104	1,882	1,436	3,320
3	47,214, ..	540	772	269	491	637	215	196	129	212	175	2,739	897	3,636
4	37,386,† ..	425	1,031	272	238	336	257	161	109	165	147	2,219	922	3,141
5	17,387, ..	172	312	116	100	226	83	67	48	40	36	967	233	1,200
6	46,122, ..	351	754	358	257	389	217	189	202	122	105	1,924	1,024	2,948
7	1,524, ..	4	16	10	13	24	10	8	5	10	7	61	44	105
8	5,060, .	7	60	39	13	36	17	7	5	13	3	208	12	220
9	18,823,‡ ..	153	357	145	111	129	63	47	36	40	34	976	139	1,117
10	23,064, ..	312	612	186	270	458	126	107	73	140	84	2,037	331	2,368
11	34,802, ..	338	585	146	168	164	148	114	66	47	58	1,554	300	1,854
12	33,588, ..	464	826	200	240	461	234	216	110	65	96	2,150	764	2,914
13	15,006, ..	8	166	55	70	88	74	44	24	39	18	477	111	588
14	240, ..	—	—	—	1	4	—	—	—	—	—	4	1	5
Total,	343,693 *†‡	3,607	6,442	2,290	2,587	3,884	1,774	1,432	1,015	1,200	917	17,862	7,289	25,151

* Exclusive of Barracks—(1,216)
† Exclusive of Workhouse—(3,525).
‡ Exclusive of Asiyum—(746).

High proportion of cases notified as "simple continued fever."

It is desirable to draw attention to a prominent feature of this table, namely, the variations which exist in the different districts in the proportions of enteric fever and continued fever and to the generally high proportion of the latter. Thus, to take a few examples—in District 1, out of a total of 1,715 cases, 1,053, or over 60 per cent., were notified as continued fever; in District 11, out of 1,854 cases, 300, or only 16 per cent., were those of continued fever; while in District 10 the proportion was a little less, namely, 14 per cent. Taking the city as a whole, out of a total of 25,151 cases notified, 7,289 were notified as continued fever, or nearly 30 per cent.

It has already been explained why, in an investigation regarding enteric fever in a community, it is necessary to take into account cases designated as simple continued fever, on the ground that a very large proportion of such cases are probably enteric fever.* But the proportion of these cases in Belfast is so large—in this respect it is probably unique—that the fact itself necessarily attracts attention. The explanation may be that it is more the custom or fashion of medical practitioners in Belfast, or of

* In the latest nomenclature issued by the Royal College of Physicians, London, it is declared that the term "simple continued fever" should no longer be used.

some of them, to notify cases as continued fever than it is in other places, and the fact that the variations are so wide in the different districts rather points to this. Evidence given by one of the Medical Officers of Health, Dr. Manley, as to his custom of notifying suspicious cases as continued fever, before the development of definite symptoms, in order to secure early removal to hospital, also suggests a similar explanation. But it is possible that there is another and, perhaps, a more important explanation, namely, that the cases of continued fever represent, in the main, anomalous departures in one way and another from typical enteric fever. If this is so, the inference would be that the prevalence of enteric fever in Belfast has been associated with an unusually large proportion of this anomalous fever, and this more so in some districts than in others.

The next table shows the attack-rates from enteric fever and simple continued fever, calculated in the manner explained, per 1,000 of the population in each sub-district. It indicates also in which water area each of these districts is situated.

TABLE V.—Showing for each Registration District in Belfast in each year since 1897 the proportion of notifications of Enteric Fever and of Simple Continued Fever per 1,000 of the 1901 population, as well as the area or areas of water supply in which each Registration District is situated:—

District.	Area of Water Supply.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Annual Average
1	Woodburn, ..	20·3	22·7	13·4	13·6	18·7	7·9	6·8	4·2	5·5	3·4	11·6
2	Almost entirely Woodburn.	11·4	12·7	6·4	8·9	13·6	4·6	3·8	3·1	4·3	2·2	7·1
3	Half Woodburn, half Stonyford.	11·4	16·3	5·7	10·4	13·5	4·6	4·2	2·7	4·5	3·7	7·7
4	Almost entirely Woodburn.	11·4	27·6	7·3	6·4	9·0	6·9	4·3	2·9	4·4	3·9	8·4
5	Almost entirely Woodburn.	9·9	17·9	6·7	5·8	13·0	4·8	3·9	2·8	2·3	2·1	6·9
6	Woodburn, ..	7·3	15·7	7·4	5·3	8·1	4·5	3·9	4·2	2·6	2·2	6·1
7	Whitewell and Woodburn.	2·6	10·5	6·6	8·5	15·7	6·6	3·9	3·3	6·6	4·6	6·9
8	Mostly local wells before, and mostly Woodburn after 1900 (Ligoniel).	1·4	15·8	7·7	2·6	7·1	3·4	1·4	1·0	2·6	0·6	4·4
9	Woodburn & Stoneyford.	8·1	19·0	7·7	5·9	6·9	3·3	2·5	2·0	2·1	1·8	5·9
10	Stoneyford, ..	13·5	26·5	8·2	11·7	19·9	5·5	4·6	3·2	6·1	3·6	10·3
11	Woodburn, ..	9·7	16·8	4·2	4·8	5·3	4·3	3·3	1·9	1·4	1·7	5·3
12	Woodburn, ..	13·8	24·6	5·9	7·1	13·7	7·0	6·5	3·3	2·5	2·9	8·4
13	Stoneyford; Mourne since September, 1901.	0·5	11·2	3·7	4·7	5·9	4·9	2·9	1·6	2·6	1·2	3·9
14	Do., ..	—	—	—	4·2	16·7	—	—	—	—	—	2·4
	City of Belfast, ..	10·5	18·7	6·7	7·5	11·3	5·2	4·2	3·0	3·5	2·7	7·3

This table shows that, in 1898, Belfast's worst year of fever, the highest attack-rates were in District No. 4 (27·6), which is situated within the Woodburn water area, No. 10 (26·5) within the Stoneyford water area, No. 12 (24·6) within the Woodburn area, and No. 1 (22·7) also within the Woodburn area; while the lowest attack-rates were (exclusive of the very small districts, 7, 8, and 14) in No. 13 (11·2) within the Stoneyford area, and in No. 2 (12·7) situated almost entirely within the Woodburn area.

In 1901, another year of exceptional fever, the highest rates were—in No. 10 (19·9) within the Stoneyford area, and in No. 1 (18·7) within the Woodburn area, while the lowest were in No. 11 (5·3) within the Woodburn area, and in No. 13 (5·9) within the Stoneyford area.

Lastly, taking the averages for the whole period, it shows that the highest average attack-rates have been in No. 1 District (11·6) which is within the Woodburn area of supply, and in No. 10 (10·3) within the Stoneyford area: while the lowest average rates have been in No. 11 (5·3) within the Woodburn area, and in No. 13 (3·9) which, prior to September, 1901, was within the Stoneyford area, and since that date has been within the Mourne area.

No relationship between distribution of fever and areas of water supply.

It is, of course, obvious from these and other figures in the above tables, as well as from the evidence of the spot maps, that the proposition that the excessive amount of fever in 1898 or 1901, or, indeed, in any other year covered by these records, has been due to the water supply, is not one easy to be entertained.

Difficulty in accepting such a proposition is increased if detailed study of the behaviour of the disease in the various districts week by week be undertaken. A very good example of an important result of this study is shown in the Diagram II., in which the weekly attack-rates of some of the registration districts are depicted. Diagram III., facing the next page, shows the weekly attack-rate in each of the registration districts in Belfast in 1898, the year of heaviest incidence of fever, while Diagram IV. shows the monthly attack-rate in four of the largest of the districts throughout the whole period which has elapsed since notification commenced.*

Diagrams illustrate essential feature of Belfast fever.

These diagrams, apart from emphasising the absence of relationship between water supply and fever, bring out one of the most important and essential facts in connection with fever in Belfast. They show, firstly, that there was a broad resemblance in each year between the total behaviour of the disease in these districts, even in those which are widely separated from one another and are situated within different areas of water supply, and secondly, that the modifications which took place within the year in this behaviour were nearly always simultaneous in all districts—that is to say, when the attack-rate rose in a particular week in one district, it likewise rose, more often than not, in the same week in the other districts, and similarly a fall, when it occurred, was practically simultaneous in all.

Consequently, in order to maintain a proposition implicatory of the Belfast Water Supply, it is necessary that thereby should be explained, not only why incidence of fever on parts of the city within the Woodburn area of supply was equally heavy, or approximately so, as on parts within the Stoneyford area of supply, or *vice versa*, but also why changes which occurred, week by week, or month by month, in the incidence of the disease generally affected diverse parts of the city *similarly*, and, above all, *simultaneously*.

Difficulty of making general facts of distribution and behaviour of fever fit in with causation by water supply.

It must be confessed that, so unlikely does it seem that any such proposition could be successfully maintained in the circumstances which have been detailed, that were the case an ordinary one, it would be permissible to dismiss the possibility of a water causation at this stage. But, plainly, the problem is not an ordinary one. On the contrary, it was laid down, at the outset of this addendum, that such a heavy incidence of fever as Belfast has suffered, so far encourages expectation that the facts will fit a theory of water causation, as to demand further means of ascertaining whether such facts cannot be made to fit in with a water causation, before dismissing such theory from consideration. It is necessary, therefore, to pursue the matter further, especially in view of the importance of the issue to Belfast.

The problem may be approached in another way, namely, by starting with an assumption that one or other of the water supplies, taking each in turn, has actually been disseminating fever, and ascertaining whether it is possible to make the facts fit in with the assumption. From this point of view, the Mourne Mountains water is obviously out of the question, since its introduction into the city has been associated with a general reduction of fever. Thus, the only supplies which need consideration in this sense are the Stoneyford and Woodburn supplies.

* All the diagrams of weekly attack-rates, whether of Belfast as a whole, of individual registration districts of Belfast, or of Maidstone, Worthing, or Lincoln, are drawn to exactly the same scale. The diagram of monthly attack-rates is drawn to one-half this scale.

The Stoneyford Supply.

Consideration first of the case of the Stoneyford supply in this way naturally suggests itself, since this supply has been mainly subject to suspicion in Belfast.

Enteric fever on Stoneyford gathering ground.

There can be no doubt that the occurrence of cases of enteric fever on the gathering ground of this supply affords presumption that the Stoneyford water may have become an agency in distributing this disease; or, to put it inversely, if it be assumed that the Stoneyford water was in fact such a distributing medium of fever, the occurrence of these cases of fever at its source might suffice to explain why it became so.

Stoneyford water could not have been responsible before 1890.

On the other hand, it is manifest that this Stoneyford water cannot have been responsible for fever in Belfast prior to 1890, the date when it was first introduced into the city; and that, consequently, even if the facts subsequent to that date can be made to fit an assumption that this supply was at fault, it would still be necessary to find some other explanation of the excessive incidence of fever before that date on what is now the Stoneyford area of supply, as well as on other parts of the city, and not least of the increase of fever which occurred in 1889.

Assuming, however, that this water was capable of disseminating fever from the date of its introduction into the city, the question first arises as to the most likely way that such an event would have been indicated. It must be remembered that the water was distributed not to Belfast generally, but to two widely separated areas of the city—one on its extreme west, the other on its extreme east. Undoubtedly, therefore, the introduction of this water into the city should have been marked, on the assumption in question, not by an increase of fever throughout Belfast, but by an increase confined to these two widely separated areas.

No evidence of increase of fever in Stoneyford areas of supply after introduction of Stoneyford water.

The Water Commissioners contended that the effect of the introduction of Stoneyford water was to reduce the mortality in the city from enteric fever, and that this reduction was maintained for some years. There can be no doubt of the truth of this contention so far as diminution of fever is concerned, if comparison be made with the year (1889) immediately preceding its introduction, as may be seen by reference to Table II. It could be contended, however, that behind this reduction of fever in Belfast as a whole, there might lie concealed an actual increase of fever in the newly-formed Stoneyford areas of supply. As to this, study of the quarterly official mortality returns of the different registration sub-districts into which the Belfast Registration District was then divided does not reveal evidence of any such increase of fever on these areas of supply.*

It might be held, however, that enteric fever had not by that time made its appearance on the Stoneyford gathering ground, and that, consequently, the Stoneyford water was not yet acting as distributing agency of the disease.

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* At this period registration district No. 3 included the present districts Nos. 3 and 10, and was therefore the district most likely to be affected, one way or the other, by the introduction of Stoneyford water. It appears from the quarterly mortality returns of the Registrar-General, that in the four years (*i.e.* 1886–1889) *preceding* the introduction of Stoneyford water the deaths ascribed to enteric and continued fever in this district No. 3 numbered 26, 23, 17, and 37, an annual average of 26; while in the four years (*i e.* 1890–1893) *succeeding* the introduction of this water they numbered 23, 34, 15, and 23, an annual average of 24.

It is true that these returns are not corrected for deaths in institutions, but making allowance for this defect, there is nothing in the figures quoted to indicate that there was a marked increase of fever in the newly formed western Stoneyford water area such as was to be looked for on the hypothesis in question in the text. Neither, it may be noted, do these figures indicate a decline of fever in this new Stoneyford water area such as would have been expected had Woodburn water been mainly responsible for excess of fever in Belfast (see page 125). The figures indicate, indeed, that the introduction of Stoneyford water had no influence at all, one way or the other, on the prevalence of fever in Belfast at that time.

ENTERIC FEVER IN BELFAST

DIAGRAM III.

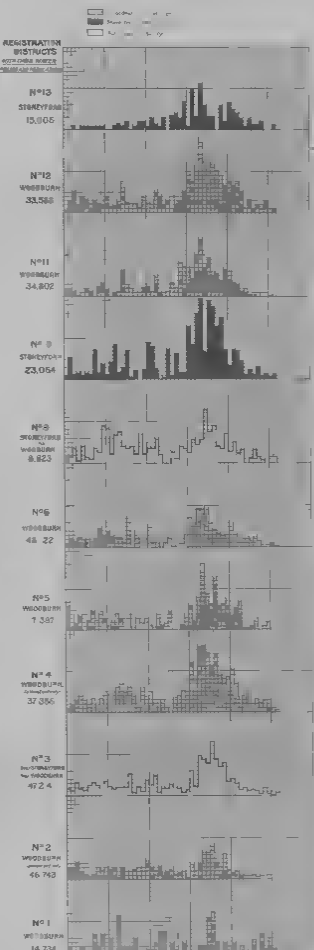

DIAGRAM Showing the approximate distribution of ENTERIC FEVER cases and deaths in the several districts, in each week of March, 1898, as recorded by the Registrar-General of Belfast.

The diagram is based on the number of the cases of enteric fever notified to the Medical Officer of Health in respect of the supply and other local causes.

ENTERIC FEVER IN BELFAST.

DIAGRAM IV.

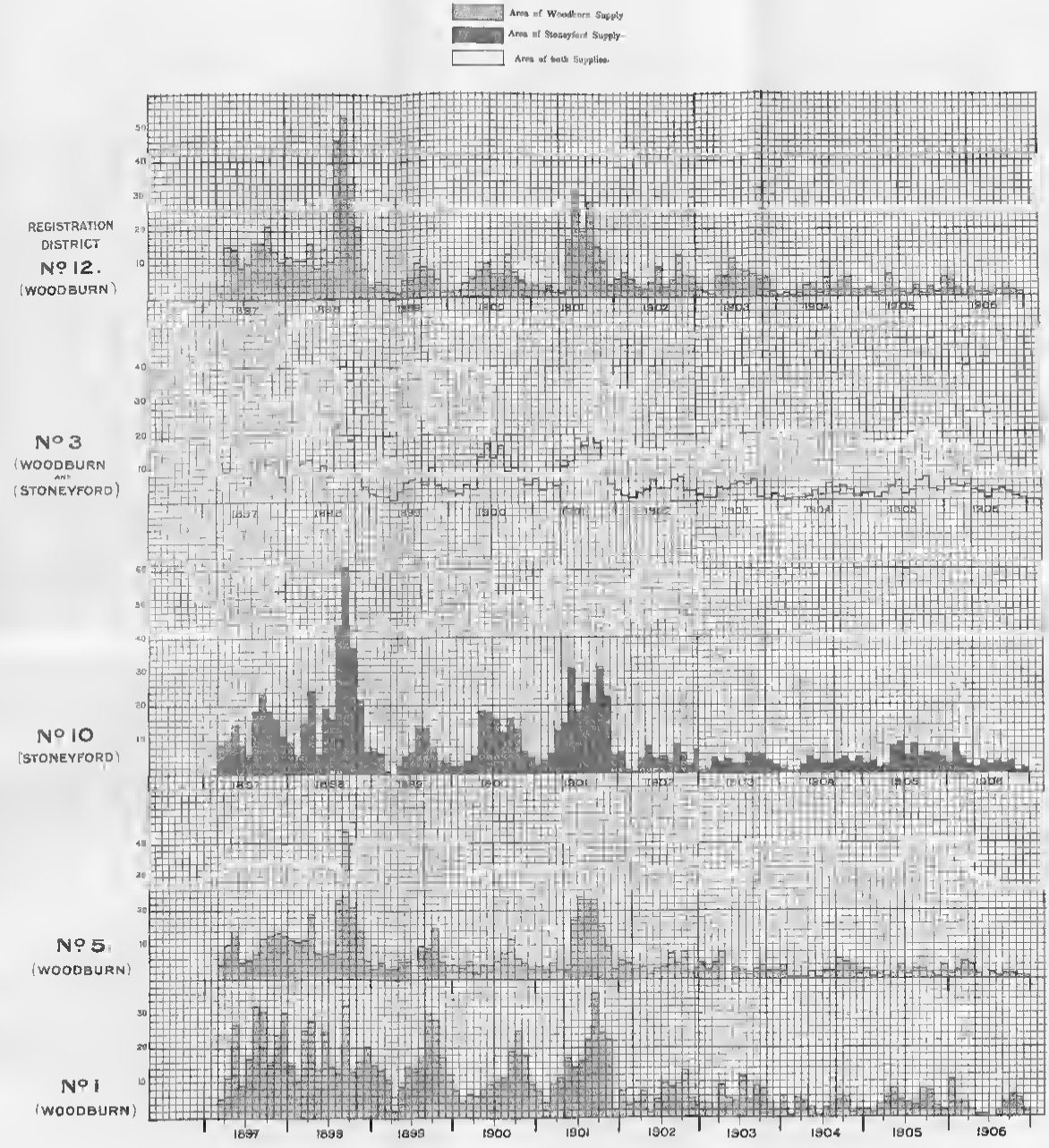

DIAGRAM IV—Showing for certain of the Registration Districts of Belfast, the approximate monthly attack-rates from FEVER (enteric and simple continued), per 10 000 of the 1901 population in each case, in each year since the commencement of notification in Belfast.

The diagram illustrates the general similarity of the behaviour of fever in various districts of Belfast throughout the period, irrespective of water-supply and other local conditions.

(The scale of this diagram is one-half that of diagrams I, II, and III.)

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It is to be noted, however, that although, for Belfast as a whole, there was a reduction of fever mortality in 1890 and subsequent years, as compared with 1889, this mortality nevertheless remained excessive; so that acceptance of the above argument would, obviously, involve the necessity of finding some other explanation for such excess.

But, putting aside this dilemma, and coming to more recent years, it may be considered whether the details of fever distribution disclosed by the notification returns, especially as regards the extra abundance of fever which began about 1897, and which was sustained more or less until 1902, can be accounted for on the supposition that the Stoneyford service had meanwhile become an agency in distributing the disease.

Increase of fever after water was filtered.

It cannot be denied that on general grounds this was somewhat unlikely. By this time, an important additional safeguard against the possibility of such an event had been established by the construction of filter beds in 1892; so that not only was all the water from the Stoneyford source subjected, as before, to settlement in vast storage reservoirs holding many months' supply, but, after that year, was also subjected to filtration.

But assuming that, nevertheless, this water became and remained capable of disseminating fever in Belfast, the question is whether it could, even so, have accounted for all the known facts of the distribution of that fever, notwithstanding what is so clearly indicated by the "spot-maps," as well as by the table of attack-rates (Table V.), and by the diagrams, namely that there has not been any of that limitation of fever to the Stoneyford areas of water supply, such as was to be expected to result from dissemination of infection by Stoneyford water.

Difference between the attack-rates from fever in the eastern and western Stoneyford water areas.

This is not all, however, for even if it were possible to explain by the influence of Stoneyford water the heavy incidence of fever in the Woodburn areas of supply, there is a notable difference between the incidence of the disease in the western Stoneyford area of supply and that in the eastern (County Down) Stoneyford area of supply which would still have to be accounted for. In 1898 the attack-rate in District No. 10 (western Stoneyford area) was 26·5 per 1,000, and in District No. 13 (eastern Stoneyford area) only 11·2, while in 1901 the attack-rates were 19·9 and 5·9 respectively In each of the other years also, the difference between the attack-rates was considerable.

This difference is certainly remarkable, and is one, moreover, which cannot be explained away by supposing that Woodburn water, and not Stoneyford water as alleged, went into the eastern Stoneyford area, for the reason that the levels rendered this impossible.

It is possible, of course, that the difference, striking though it be, may be capable of some explanation. For, although with water-borne fever the common experience is that no considerable part of the community to which the responsible water has access is spared from attack, it is not unusual to find some inequalities in the extent to which particular sub-divisions of the community suffer. These inequalities are, no doubt, due to differences in the susceptibility of the populations concerned, to differences in their age-constitution, to interruptions in the water service, and to other accidental circumstances, particularly such as may be thought of as likely to interfere with the absolutely uniform circulation of solid particles of matter which are in suspension, as micro-organisms are, and not in solution in the water.

It needs to be pointed out, however, that the age constitution of District No. 13 at the 1901 census does not appear to satisfactorily account for the relatively small amount of fever in this district. On the contrary, it might reasonably be contended that the age constitution of its inhabitants rather favoured invasion of that district by enteric fever.

Moreover, the arrangement by which Stoneyford water was conveyed to the eastern side of the city was not, apparently, of a nature to account for the relatively small incidence observed there; this arrangement comprising, as it did, an isolated main 2½ miles or more in length which traversed the city from west to east and passed through low levels *en route*. With a constant service of water, which Belfast has had for many years, and with water under considerable pressure as in this case, it is difficult to understand how such a length of main could have sufficed to impede the transmission of infective material towards the eastern Stoneyford area.

It is difficult, therefore, to see what explanation, on the supposition that Stoneyford water was disseminating fever, there can be of the remarkable differences as regards amount of fever in these Stoneyford areas of supply, west and east of Belfast. Let it be assumed, however, that they can be accounted for in some way, in order that it may be considered whether the remaining known facts as to fever distribution can be accounted for on the supposition in question.

It must be remembered that these facts, since 1897, are such that it will not suffice to show that the Stoneyford water could have caused fever solely in its own water area and to find other explanation of the fever elsewhere; for, as already indicated, and as shown by the diagrams, the behaviour of the disease was, on the whole, so similar, and the changes in this behaviour were, on the whole, so simultaneous in the various divisions of the city, whether supplied with water from Woodburn or with water from Stoneyford, that it is an essential part of the problem to find a satisfactory explanation of these coincidences.

In these circumstances, it is quite plain that, in order to make the facts fit in with a theory of causation of fever by Stoneyford water, it is necessary to show that this water was habitually supplied, not only to its own accredited water areas in the city, but elsewhere also.

Connections between Stoneyford and Woodburn distributing mains

The Water Commissioners admitted that the Stoneyford distributing mains are connected at many places in the city with the Woodburn mains, and that on occasions one or other of these connections are opened so as to permit Stoneyford water to pass into Woodburn mains; but they maintained that this had never been done except in times of emergency, such as might be brought about by the bursting of a main or by the necessity for repairing or relaying a main. No detailed records, however, have been kept of the occasions when these connections between the two systems of water mains have been opened.

The Water Commissioners also maintained that the long Stoneyford main which traversed the city from west to east was an absolutely isolated main, that is to say, that although connections with Woodburn mains existed in many places in its course (it had been a Woodburn main before the introduction of Stoneyford water and has become a Woodburn main again since the introduction of the Mourne supply), as matter of fact none of these connections had been opened except those at either end.

Impracticable for Stoneyford water to be supplied habitually to Woodburn water areas

And, lastly, they not only maintained that on no occasion had Stoneyford water been supplied to the whole city, but also that, so far from there being any probability of the whole, or even a large part of the Woodburn areas having been supplied habitually with Stoneyford water, the possibility of such occurrence was quite out of the question, for the reason that the amount of water available from this Stoneyford source (3 million gallons per day) was altogether inadequate for such habitual service.

Stoneyford water insufficient to permit of this.

It must be admitted that there can be no question as to this latter contention. Stoneyford water, besides being limited in quantity, was, before 1901, the only high pressure water available for the supply of the city, and consequently the Water Commissioners had every reason to be careful of its use, lest their sole means of supplying the higher areas of the city should

become deranged, such as might have happened if it had been usual to allow this water to pass in considerable quantities into the Woodburn area of supply, where 9 million gallons constitutes the daily consumption.

The possibility of the habitual supply of Stoneyford water to the Woodburn area of supply can therefore be excluded.

Possibility of Stoneyford water being supplied occasionally to Woodburn areas.

On the other hand, in the absence of records as to the opening of connections between the Stoneyford and Woodburn mains, it is permissible perhaps to suppose, without questioning the good faith of the witnesses who spoke to the contrary, that Stoneyford water may have passed to one or other portions of the Woodburn area of supply on occasions more frequent than the Water Commissioners' officers were able to recollect; or even to surmise that this water may have been supplied, if not to the whole, at least to the greater portion of the city on some particular occasion or occasions of brief duration. At all events, the possibility of such occasional occurrences cannot be excluded, in the way that the possibility of the *habitual* supply of Stoneyford water to Woodburn areas can be.

The question might arise, therefore, whether the facts as to fever in the Woodburn areas of supply can possibly be accounted for by assuming that Stoneyford water, though not habitually supplied, did, as matter of fact, occasionally pass for brief periods of time, and more frequently than is believed, to large sections of the Woodburn areas.

In this connection the behaviour of the disease in these Woodburn areas, as apart from its precise distribution, becomes of the highest importance. If, for instance, the features of the problem to be solved had been comprised of an explosive outburst of fever affecting the Stoneyford areas of supply primarily, and, in immediate sequence or even simultaneously, the greater part of the Woodburn area, it might have been possible to account for such outburst by fixing responsibility on Stoneyford water, on the assumption that the outburst had coincided in point of time with one of the brief occasions of Stoneyford water being supplied to Woodburn areas.

On the other hand, if there had been, habitually, a strikingly smaller incidence of fever on the Woodburn areas of supply generally than on the Stoneyford areas of supply, together with occasional localised increases of fever in the former, it might also have been possible to attribute such manifestations primarily to Stoneyford water. In such circumstances, the habitually small incidence of fever on the Woodburn areas might have been ascribed to the occurrence therein of only "secondary" cases of the disease, while the occasional localised increases of fever might have been associated with the occasional passage of infected Stoneyford water into Woodburn water mains.

But the essential conditions of the problem which has to be solved are totally different from those hypothetically stated. As matter of fact, parts of the Stoneyford areas of supply and parts of the Woodburn areas of supply were both heavily affected from at least 1897 to 1902; both suffered to much the same extent; both exhibited not only broad similarity, but also simultaneity in their response to the disease; and all this not for a brief period only, or even for one or two brief periods, but for a very prolonged period.

The actual facts, indeed, are such that the only conceivable way to account for them, on the assumption that Stoneyford water was responsible, is to suppose that this water passed into the Woodburn mains, not occasionally but constantly, or more or less habitually, throughout this long period, and also that it so passed in no inconsiderable quantities.

It is quite clear that this is a supposition which cannot be seriously entertained.

Belfast fever cannot be explained by dissemination by Stoneyford water.

The conclusion is inevitable, therefore, that the facts of the case, so far as they are known, cannot be made to fit in with a theory that Stoneyford water disseminated fever in Belfast, and that, consequently, this section of the water supply cannot be held responsible for that fever.

This conclusion is strengthened by certain other features of the problem which have not been alluded to, and which it is now perhaps needless to discuss. But it is desirable to note that even if it had been possible to explain the general incidence of fever in Belfast by holding Stoneyford water responsible, it would have been none the less necessary to explain why the small town of Dunmurry, which lies to the south-west of and outside the city boundaries, escaped, notwithstanding the fact that Stoneyford water has been supplied to it since 1900, and the circumstance that this water passes into this area of supply *before* it reaches Belfast.

Summary of facts relating to Stoneyford supply.

It may be convenient to summarise the case in regard to the Stoneyford supply by setting out in parallel columns the actual history of Belfast fever, and what it might have been expected to be had Stoneyford water been its main agency from the date of its introduction—had this water been capable, that is, of disseminating fever more or less persistently, but not to such an extent as to cause an explosive epidemic.

A. History of Belfast fever, as it should have been, had Stoneyford water been its main agency.	B. Actual history of Belfast fever.
1. Absence of fever in abnormal amount in Belfast until July, 1890.	1. Presence of fever in abnormal amount in Belfast from 1872 onwards, and especially in 1889.
2. Undue fever after July, 1890, but mainly limited to the Stoneyford areas of water-supply.	2. Reduction of fever for some years after 1889, and no evidence of special incidence of fever on the Stoneyford areas of water-supply.
3. Similarity of incidence of fever on various sections of Stoneyford areas of supply.	3. Great dissimilarity of incidence of fever on various sections of Stoneyford areas of supply.
4. So little fever in the Woodburn areas of water-supply that such could reasonably be accounted for as due to secondary causes.	4. Evidence that Woodburn areas of water-supply suffered as heavily as Stoneyford areas, of water supply, even before 1897, since which date the notification records prove that they have done so.
5. Occasional tendency of fever in Woodburn areas of supply to increase for brief periods in localised areas, owing to the occasional opening of connections, here and there, between Stoneyford and Woodburn mains.	5. Marked tendency of fever in Woodburn areas to increase simultaneously with increase in Stoneyford areas, and generally to the same extent.
6. Marked reduction of fever in Stoneyford areas after 1892, when filtration of this water was commenced.	6. Great increase of fever affecting both Stoneyford and Woodburn areas subsequent to 1892.
7. Increase of fever in the village of Dunmurry after introduction of Stoneyford water in 1900.	7. No increase of fever in the village of Dunmurry—reduction rather after 1900.

The Woodburn Supply.

It is now necessary to discuss the matter on the assumption that Woodburn water has been capable of disseminating the disease.

Woodburn supply has had opportunity of disseminating fever for upwards of 30 years.

The first consideration which arises from this point of view is that if any water supply has disseminated fever in Belfast, this one, assuming its ability, had the completer opportunity of doing so.

For twenty years or more prior to 1890, the date of introduction of the Stoneyford water, the Woodburn water-works practically served all of the inhabitants, and after that date until the end of 1901 they continued to serve the vast majority of them, so that if water has been disseminating fever at all, this Woodburn supply, and this supply alone, has had opportunity of doing so at any time during the whole period of upwards of thirty years in which the disease has been so excessive.

Deterioration of Woodburn gathering grounds after 1871.

Moreover, there are certain circumstances in connection with this Woodburn supply which may at least be regarded as possibly tending to render it a fever agency. Thus it might be held that the "deterioration" of the Woodburn gathering ground which took place in the decennium 1871-1880, as result of a part of this area being "broken up" into farms with consequent increase of population on the catchment area, might possibly furnish explanation of the excessive amount of fever in Belfast in that decennium, and even its subsequent increase in 1889; while the improvement of this gathering ground which has taken place since 1901 in consequence of the purchase and clearance by the Water Commissioners of many farms, might be held to account for the diminution of fever which has taken place in Belfast since that date.

Defective conduit from Woodburn to Belfast.

Again, since the conduit which conveys this water from the gathering ground to the filter beds in Belfast, a distance of nine miles, has required repair on several occasions on account mainly of the nature of the ground in which it is laid, possibilities of pollution reaching the water in its course through this channel might be thought of as furnishing other not unlikely explanation of a fever distributing capability of this service. The Commission were told in evidence that certain streams which passed above this conduit had been diverted from time to time partly because they were regarded as possible sources of pollution of the water flowing through it. Furthermore, it was also admitted that a certain, though small, amount of water might enter the conduit from the gathering ground without passing through any of the great storage reservoirs which are such a prominent feature of both this and the Stoneyford systems.

No evidence of enteric fever on gathering grounds.

Moreover, although cases of enteric fever are not known to have occurred among the inhabitants of the Woodburn gathering grounds, it is possible that cases of unrecognised enteric fever may have occurred there, or that infected town manure may have been used either on the gathering grounds or in the neighbourhood of the conduit, and that specific infection of this water might be thus explained.

Reduction of fever in Belfast after 1889, but not especially in Stoneyford water areas.

On the other hand, it becomes difficult to understand how it happened that the introduction of Stoneyford water caused no marked improvement in the areas of the city where it displaced the Woodburn supply. Obviously, if Woodburn water had been at that time disseminating fever in Belfast, there should have been a great improvement after 1890 in the new Stoneyford areas of supply; but although, as has been shown, the introduction of this water coincided with some reduction of fever mortality in Belfast as a whole, it does not seem to be the case, as far as may be judged from the quarterly mortality returns of the period, that there was any appreciable reduction of mortality in these new Stoneyford areas of supply.*

Increase of fever after water was filtered.

Furthermore, it also becomes difficult to understand why, if Woodburn water was distributing fever, no improvement took place, in at least the Woodburn areas of supply, subsequent to the date—February, 1894—after which all this water was filtered before being delivered to consumers. Moreover, there is no evidence in the daily records of the filter works that there had been at any time any interruption of filtering operations of a sort likely to arouse suspicion that it had been necessary to utilise unfiltered

* See footnote on page 120.

water. Nevertheless, the amount of fever increased after the above date very largely indeed, this increase affecting, it is to be noted, not only the Woodburn areas of supply but the Stoneyford areas of supply as well.

But, putting aside these obvious difficulties in the way of connecting Belfast fever of the past with this Woodburn supply, it may be considered whether the facts relating to the distribution and manner of incidence of fever in Belfast since 1897, when the notification data became available, can be made to fit the theory that Woodburn water was responsible for that fever.

Incidence of fever on Woodburn water areas very great.

Apparent effect of introducing Woodburn water into Ligoniel.

It has been shown that the incidence of fever on the Woodburn area of supply has been very heavy. In 1898, indeed, one of the districts (No. 4) in this water area suffered more heavily than any other district in the city; and in 1901 another of these districts (No. 1) was also one of those most affected. Again, the effect of introducing Woodburn water in 1900 into Ligoniel (District 8), in the extreme north-west of the city, might be adduced in confirmation of the suspicion that this water was responsible for fever. In 1898 this district, supplied then by local wells, suffered from fever like the remainder of the city, and it was supposed that the water yielded by these wells had been responsible for the prevalence in this outlying district. But in 1900 Woodburn water was introduced, an event which was followed in 1901 by a large increase of fever there. (See Table V.)

On the other hand, it is obvious from the "spot maps," the details of attack-rates in Table V., and the diagrams, that there has not been, since 1897, any limitation of fever to the Woodburn areas of water supply, such as was to be expected to result from the dissemination of fever by Woodburn water.

Differences of incidence of fever on different sections of the Woodburn area of supply.

Moreover, the table of attack-rates shows that there were differences in the incidence of fever on the various sections of the Woodburn area of supply, which were quite as striking as they were in the case of the Stoneyford areas of supply. Notable examples of these differences are to be found in District 1 and 2 which adjoin one another, and in Districts 11 and 12 which also adjoin one another.

Adequate explanation of these differences, on the supposition that Woodburn was mainly responsible for Belfast fever, is just as difficult as it proved to be in the case of the differences of incidence on the Stoneyford areas of supply, when discussing the possible responsibility of Stoneyford water.

If it be assumed, however, that they can be explained in some way, it would still remain necessary to ascertain whether there is any possibility of holding Woodburn water responsible for the fever witnessed outside the Woodburn areas of supply, and particularly for its excessive incidence on the western Stoneyford area of supply.

Difference between fever in east and west Stoneyford water areas.

Can fever in west Stoneyford area be accounted for by Woodburn water?

In this connection the striking difference, already referred to, between the attack-rate from fever in the eastern Stoneyford area of supply and that in the populous part of the western Stoneyford area (District No. 10) might suggest as a possible explanation that the incidence of the disease in the eastern Stoneyford area reflected truly the minor effect of Stoneyford water, and that the incidence on the western area was really the result of the influence of Woodburn water. From this point of view, therefore, the question is whether the incidence of fever in this western Stoneyford area can be explained on the supposition that Woodburn water caused it; whether, that is, although District No. 10 is said to be within the Stoneyford area of supply, it is possible that it has actually been supplied habitually with Woodburn water. It will be remembered that this district was so supplied before the introduction of Stoneyford water.

But the Water Commissioners showed clearly that the levels of this district are such that Woodburn water cannot reach it, except by means of the Ballyaghagan reservoir into which it used to be pumped for that purpose prior to the introduction of Stoneyford water. Further, they not only showed that shortly after the Stoneyford water became available, this reservoir was used solely for Stoneyford water, but also that it then became physically impossible to send Woodburn water into it for the reason that the necessary pumps were dismantled. The possibility of Woodburn water reaching this district *vid* the reservoir which now supplies the still higher district of Ligoniel is also excluded, because the Ligoniel mains have no connection with those in the remainder of the city.

Impossibility of supplying west Stoneyford water area with Woodburn water after 1890.

It is clear, therefore, that incidence of fever on No. 10 District after 1890 cannot be explained by consumption of Woodburn water in that district.

Had this been the only reason for excluding Woodburn water as an agency of Belfast fever, the question might have arisen whether it was possible to account for fever in No. 10 District by a supposition that the sufferers, resident in that district, contracted the malady by consuming Woodburn water outside the district.

The very heavy incidence of fever on this district—in 1901 it was the worst district of all, and in 1898 it was one of the worst (see Table V.)—obviously makes such an explanation very unlikely. On the other hand such an explanation seemed to be just possible, because it appeared that a considerable number of persons resident in No. 10 District actually work in other districts where the only supply of water is that from Woodburn. Further inquiry, however, revealed that nearly all of these outside workers are men engaged in the shipbuilding industry; while it also appeared that a very large number of residents in No. 10 District, probably the majority, work within the district, and that most of these are women engaged in the flax-spinning industry.

The notification records supplied by the Corporation do not include data as to the occupations or ages of the sufferers—and this affords a striking example of how important it is to have such data—but it is possible to ascertain from figures, which have been supplied, regarding the sex of those notified as suffering from fever in this district, that both in 1898 and 1901 females in this district suffered very heavily indeed from fever, though, as is usual according to experience, not so heavily as males.*

Heavy incidence of fever on females working in District No 10 as well as on males working outside.

The figures in question are as follows:—(Population of No. 10 District in 1901—males, 10,452; females, 12,612).

—	Notifications of Enteric and Simple Continued Fever.		Attack-rate per 1,000 living.	
	1898.	1901	1898	1901
Males, ...	323	219	31	21
Females, ...	289	239	23	19

These figures, while not inconsistent with both sexes having been subjected to one and the same cause of infection within the area in which they reside, are certainly not consistent with males only having been subjected to a cause of infection outside the district.

There is, therefore, no means of explaining the manifestation of fever in No. 10 District in these worst years by the influence of Woodburn water, although, clearly, if Woodburn water had been responsible for Belfast fever,

Woodburn water cannot be made to account for fever in Belfast.

* The enteric fever attack-rate is usually higher among males than females. Thus, in the Lincoln epidemic the attack-rate for males was 22·8 per 1,000, and that for females 16·6 per 1,000, or 27 per cent. less. In London, 1905, the female attack-rate (·28 per 1,000) was 26 per cent. less than the male attack-rate (·38 per 1,000). Data as to incidence on sex in the Worthing and Maidstone epidemics are not available, but in a large epidemic at Newport, Isle of Wight, the attack-rate on males and females was 44 and 39 per 1,000 respectively.

this feature of its distribution should have been readily explicable. Also, there seems to be no means of explaining the manifestation of fever in Belfast, after the introduction of Stoneyford water, by the supposition that Woodburn water was responsible for disseminating the disease. Having regard therefore to these facts, as well as those previously detailed, relating to the general behaviour of the disease, namely its broad similarity and simultaneity in the various sub-divisions of the city, and the necessity of finding a satisfactory explanation of these features, the conclusion cannot be avoided that the theory of dissemination of infective material by Woodburn water cannot be made to explain the distribution of fever in Belfast.

This conclusion gets support from a consideration not yet alluded to, viz., that the town of Carrickfergus, some eight miles east of Belfast, has escaped serious invasion of fever, although at least half of its population has been served for many years with water from Woodburn, and moreover with unfiltered Woodburn water.

It has now been shown that neither in the case of the Woodburn supply, nor in the case of the Stoneyford supply, can the facts as to the distribution of fever in Belfast be made to fit in with a theory that either of these supplies was disseminating the disease from their sources, and, that, consequently, their responsibility, individually, for fever in Belfast must be set aside.

But, undoubted as this conclusion seems to be from the facts of the case so far presented, it would appear that yet another and most important obstacle to acceptance of a theory of either public water supply as the main agency of fever year after year in Belfast has to be considered.

Fever in Belfast has not affected all classes of society.

It has already been explained that the common experience of fever waterborne by a public service has been, as may be readily understood, that no large sections of the community served by the implicated water are spared. Fever so caused has not respected different grades of society. In Belfast, however, it would seem that although the fever was widespread and abundant, it by no means universally affected all classes. This may be seen on comparing the "spot maps" with the copy (reproduced) of a map, furnished by the Belfast Corporation, on which is indicated the distribution of population in Belfast, the locations of the working class population being distinguished from those of other classes.

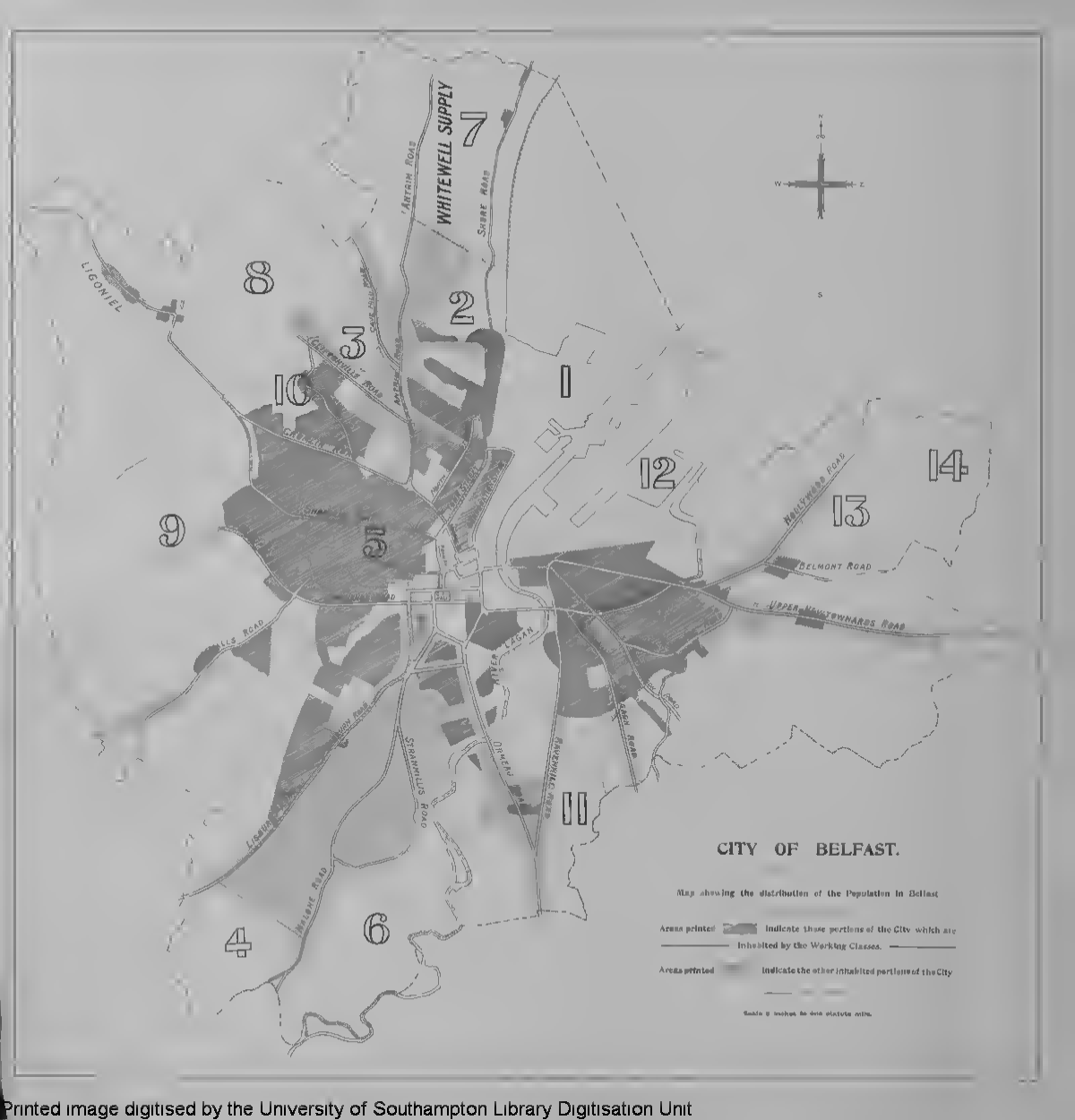
Fever has been mainly limited to the working classes

From these maps it is evident that the fever areas are limited, almost entirely, to the quarters of the city occupied by the working classes: and that other classes of the population enjoyed relatively complete freedom from the disease. The limitation thus indicated by these maps, is, it may be added, one which applies also to the distribution of fever in every year for which spot maps are available. For reasons already explained, there are no statistical data obtainable in confirmation of the evidence supplied by these maps, but it seems to be sufficiently striking without such data.* Confirmation is, however, obtained, if such be needed, from the evidence submitted to the Commission of the immunity enjoyed by the population resident in institutions, by persons living in the residential quarters of the town, and by the Jewish community. This evidence, though not of much weight perhaps in individual instances, becomes of great interest in the light of the facts demonstrated by the maps.

Water service could not account for fever so limited even if it had been derived from one source.

Such absence of a universal incidence of fever on all classes of the community would have been practically conclusive against a thesis of water causation, even if Belfast had been served with water from one source only; for it would have been out of the question to accept such a thesis, and at the same time to believe that the water had been able to discriminate, year after year, between the working classes and other sections of the population. Obviously, it is also conclusive with water supply coming from two sources even on the extreme assumption that both water supplies disseminated the disease simultaneously.

* It may be added that as result of a special visit to Belfast, the indications of these maps were found to be remarkably accurate.



Before leaving the subject of water supply it is perhaps desirable to point out that the apparent effect of the introduction of Mourne water in reducing fever in Belfast as a whole is open to question. Many people in Belfast appear to have entertained the belief that the reduction of fever which has followed the introduction of Mourne water has been due to the influence of this water, and that it, therefore, points at least to the dissemination of fever previously by the older supplies. But clearly if the introduction of Mourne water had been the cause of this reduction of fever, it should have been most manifest in what has been called the eastern Stoneyford area of supply, which, since September, 1901, has been served with Mourne water only. As matter of fact, however, the reduction of fever in that area since the Mourne water became available has been relatively less than in other districts—indeed reference to Table V will show that in District No. 13 there was even a slight increase of fever in 1902, the first complete year in which it was supplied from the Mourne Mountains as compared with 1900, the last complete year in which it was supplied from Stoneyford.

Apparent effect of introduction of Mourne water in reducing fever in Belfast.

The following table compares the records, not for individual years, but for two periods of years, viz :—1899–1901 and 1902-1904, in District No. 13, supplied since the end of 1901 with Mourne water; in District No. 10 supplied in both periods with Stoneyford water; and in Districts Nos. 1, 4, and 12 supplied in both periods with Woodburn water, but largely mixed with Mourne water in the second period :—

Effect not real; apparent only.

District.	Water Supply.	Approximate mean annual attack-rate per 1,000 from fever during—		Reduction percentage in second period.
		1899–1901.	1902–1904.	
No. 13,	Stoneyford in 1st period, Mourne in 2nd period,	4·7	3·1	34
No. 1,	Woodburn in both periods.	15·2	6·3	59
No 4,	Mixed with Mourne in 2nd period.	7·5	4·7	37
No. 12,		8·9	5·5	38
No. 10,	Stoneyford in both periods,	13·2	4·4	67

It is thus seen that the reduction effected in the district supplied entirely with Mourne water in the second period was the least, and that the reduction effected in the district (No. 10) to which no Mourne water has been supplied was the greatest, while the districts supplied during the second period with Woodburn water mixed with Mourne water occupy an intermediate position.

It is clear from these figures that it is extremely difficult to maintain a proposition attributing the reduction of fever, which has occurred in Belfast since 1901, to the introduction of the Mourne water.

Introduction of Mourne water cannot account for reduction of fever.

It may be convenient at this stage to briefly recapitulate. It has been shown that explanation of the excessive amount of fever in Belfast on the score of insanitary conditions, is not consistent with the facts; and that there must have been some other dominant agency of fever operating by itself, or in addition to the effect produced by these insanitary conditions. This conclusion was arrived at partly because it was found that the distribution of fever did not coincide with areas exhibiting those insanitary conditions, but involved other and comparatively sanitary areas as well; partly because the amount

Recapitulation

of fever largely increased at a time when, in view of the considerable improvements in a sanitary sense which had been effected in Belfast, and of the associated improvement not only in the general health of the city but also in the incidence of zymotic maladies otber than this particular disease, it should have evinced instead a tendency to diminish; partly because fever in Belfast was at almost its lowest level more than 20 years ago; and partly because Belfast suffered from fever more severely, over series of years, than any other town in the United Kingdom.

It has also been shown that to attribute Belfast fever to the water supply of tbe city is likewise not consistent with the facts; this conclusion having been arrived at, because, since 1897, the distribution of fever did not and could not be made to correspond with the distribution of water of either section of the public water supply, and also because the disease does not appear to have affected all classes of the population, having been limited instead mainly to the working classes. Prior to 1897, there is no evidence that the behaviour of Belfast fever differed materially from its behaviour since that date, while the introduction of Stoneyford water appears to have had no appreciable effect on that behaviour in the areas of the city which it was supplied.

It may be inferred from this brief recapitulation that two of the most striking features of the recent history of fever in Belfast are :—

(*a*) Its large increase at a time when, instead, its diminution was to be looked for; and

(*b*) Its limitation mainly to the working classes;

and it is obvious that an agency must be looked for which can explain both of these features.

Thus, if the problem be approached with these two features in view, it becomes clear that the second cannot be explained by a theory of water causation, whatever view might be held as to the possibility of explaining the first on this basis.

Likewise it becomes clear that the first feature cannot be explained by a theory of causation mainly by insanitary conditions, whatever view might be held as to the possibility of explaining the second feature in this way.

Relation of milk supply to fever in Belfast.

In the same way the milk supply of the city can be excluded, for not only can it not explain the above special features, but also, in consequence of the diversity of sources from which it is derived, it cannot be thought of as at all likely to furnish any explanation of otber prominent features of the problem. It may be surmised, however, that here and there localised outbreaks have depended on dissemination by milk; indeed, it was given in evidence that several "milk outbreaks" of fever have been known to have occurred from time to time.

The Windsor milk outbreak in Belfast in 1906.

In this connection reference may be made to a prevalence of enteric fever in 1906, which mainly affected a residential district in the south of Belfast known as Windsor, and which was regarded as having been disseminated by a particular milk supply. It is desirable to refer to this prevalence for two reasons—first, because it formed a notable exception to the prevailing limitation of fever to the working classes; and, secondly, because the Corporation claimed that their experience of ir revealed a defect in the provision expressly made by Parliament—Section 4, Infectious Diseases (Prevention) Act, 1890—to enable local authorities to prohibit the sale of milk causing or likely to cause (notifiable) infectious disease. Tbe facts of the prevalence were briefly as follows :—

A localised group of cases of fever were notified in Belfast in a period of two months commencing in August, 1906, among the customers of a certain milk purveyor, whose place of business was outside the city, and during the same period cases occurred outside the city also among this purveyor's customers.

Suspicion having been aroused by the restriction of fever to the customers of a particular milk purveyor, the Corporation at an early stage availed themselves of their power, under the provision of the statute above referred to, to cause examination to be made of the purveyor's place of business; of the cows from which the milk in question was derived; and of a sample of the milk itself; as well as to direct inquiry into the health of the persons who were concerned in the milk business. The result of this action was in the first instance negative on all points. Thus it was

stated that the premises were found to be in a satisfactory condition; that the cows showed no symptom of disease or ill-health; and that the sample of milk failed to reveal the presence of *Bacillus typhosus* or even of micro-organisms indicative of fæcal contamination, so that the bacteriologist, Professor Symmers, was led to declare that "this milk could not communicate typhoid fever to those drinking it"; while, lastly, assurance was received from the Medical Officer of Health of the district, who happened also to be the medical attendant of the milk purveyor, that he was not aware of "any case of sickness that has occurred recently" among the occupants of the purveyor's premises, and that no infectious disease had occurred there for at least ten years.

In consequence of the negative results of these investigations, the Corporation did not take steps to prohibit the sale of the suspected milk in the city in the manner laid down by the statute, and they contended that legally they were powerless to do so. The basis of this contention was, briefly, that such steps cannot be taken unless, as result of the "inspection" authorised by the first sentences of the provision of the statute, actual proof, or something approaching actual proof, is forthcoming that the source of the suspected infection of the milk has been discovered; and that this inability to take such action remains so long as such proof is absent, no matter how strong may be the proof from circumstantial evidence that the disease is being disseminated by the milk.

As cases of enteric fever continued to occur among the customers of the implicated milk business, further inquiries were made by the officers of the Corporation, assisted by the Chairman of the Public Health Committee, Dr. King Kerr, and the sequel is instructive. It appeared that one of the milkers employed by the purveyor had suffered from an illness some three months previously, a circumstance which had been forgotten by the local Medical Officer of Health (though he himself had been the medical attendant) when he stated, in response to the earlier inquiries, that there had not been any recent sickness among the persons concerned in this milk business. The illness in question had not been of a severe nature, and had not disclosed in its symptoms any resemblance to enteric fever,* but it was now discovered that a sample of blood obtained from this person yielded a positive "Widal" reaction with cultures of *B. typhosus*

Soon after this discovery, the distribution of the implicated milk in Belfast was stopped voluntarily, though under protest, by the vendor; but some two months had then elapsed after suspicion had been first directed to it. The localised fever outbreak thereafter ceased.

It must be left to lawyers to determine whether the Belfast Corporation were correct in their interpretation of the law upon which they abstained from action at a time when the actual source of mischief was not apparent. But assuming that they were, it would seem that the circumstances of this particular case, so far from disclosing of necessity a defect in the law, really provide a very forcible illustration of the need for exhaustive and minute inquiries in outbreaks of disease suspected to be disseminated by milk. It is clear, as, indeed, subsequent events proved, that it would have been possible to discover the real bearing of the milker's illness at an early stage of the investigation, if the inquiries had been sufficiently exhaustive, just as it became possible to do so at a late stage; and that, although it may be conceded that, for the failure to do this at an early stage, the Corporation officers were scarcely in the circumstances to blame, it certainly cannot be contended that such failure was attributable to any defect in the law. If, in fact, the illness in question, and its real bearing had been discovered at an early stage, question as to the ability of the Corporation to take action would not have arisen.

Windsor outbreak emphasises the limitation of fever in the main to the working classes.

This milk outbreak serves, however, another useful purpose, since, owing to its incidence mainly on a residential part of the city, it formed a notable exception to, and thereby emphasises, the limitation of fever in the main to the working classes in Belfast. Furthermore, it shows that, given the opportunity, all classes of the population, the wealthy as well as the poor, are as liable to attack by enteric fever in Belfast as elsewhere.†

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* The Medical Attendant states that he visited the patient on six occasions in a period of about sixteen days, and that his diagnosis was "Influenza, bronchitis, jaundice." He adds in a letter to the Corporation on the subject: "My recollections of the case are that she suffered very much from severe cough and dyspepsia; there was some congestion (fine crepitation) at the base of both lungs. This improved greatly in about a week or so, and then I recollect going back and finding her suffering from severe pain on gall bladder and constipation, jaundice supervening about a day afterwards. I consider the attack was most probably due to the passage of a small gall stone. The jaundice disappeared in a few days, and I found her sitting up when I went back. There was nothing in the attack that would lead me to suspect that there was anything in the case otherwise than what I have described. I regret that I quite forgot about her case when replying to your former letter."

† It is interesting to note that, according to information given by Sir Otto Jaffé since the taking of evidence closed, the only cases of enteric fever which have occurred among the Jewish community in Belfast during the last ten years or more occurred in connection with the Windsor milk outbreak referred to above.

Proneness to fever among working classes general in Belfast.

It is obvious, therefore, that this limitation of fever in Belfast in the main to the working class population is a not unimportant element of the problem under consideration; and it becomes all the more important when it is noted that, according to the evidence of the "spot maps," the disease was not merely limited to the working classes, but also that it appears to have involved the working classes more or less generally.

When, in addition to this, it is recalled that, as has been previously shown, one of the most essential features of fever in Belfast has been the way in which it has affected diverse parts of the city more or less similarly in each year and on the whole simultaneously, it seems clear that an agency of fever requires to be found which can be shown to be capable of affecting the working classes not only almost exclusively, similarly, and simultaneously, but also generally; capable, that is, of affecting them simultaneously, whether they live in the central or in the outlying parts of the city; in low-lying or in elevated situations; in new houses or in old houses; among grossly insanitary surroundings or under conditions more conducive to health; and, presumably, irrespective also of the occupations engaged in by them.

SHELLFISH.

With the issue narrowed in this way, the question of necessity arises whether in shellfish there may not be found a factor capable of explaining this proneness to fever of the Belfast working classes. It is well-known that in Belfast the working classes generally are consumers of this article of food, and that they are practically the only consumers of certain kinds of shellfish, namely, those which are obtainable in abundance in Belfast Lough almost at their very doors. The shellfish thus locally obtainable are periwinkles, mussels, and cockles, but not oysters. Oysters have been practically extinct in the Lough for many years.

Two considerations are involved—first, whether the consumption of these shellfish by the working classes in Belfast is or has been large; and, secondly, whether the shellfish so consumed are liable to be exposed to such contamination as would be likely to cause them to become an agency of fever.

Very large consumption of shellfish by Belfast working classes.

As to the first consideration, there is much evidence to the effect that the consumption of shellfish by the working classes in Belfast has been very large indeed. A witness, himself engaged in the shellfish trade, informed the Commission that the gathering of shellfish from the shores of the Lough by professional gatherers had been an important Belfast industry for "more than half a century." There has been a considerable export* of periwinkles and mussels, for use as human food, to seaport and inland towns in England, even to London in the case of periwinkles; and also a large export of mussels for use as fish bait to various other places. Cockles, on the other hand, have not been largely exported, but have been almost entirely consumed locally. The witness referred to stated that the local trade in cockles, and to a less extent that in mussels and periwinkles also, had been very large. Speaking of a few years ago, he said that there were 20 or more professional gatherers who once a day at least collected cockles from the shores of the Lough, unrestricted by any close time or licence, and who every evening hawked them for sale in the working class streets of the city. He estimated that some 700 to 800 quarts of cockles were sold in this way every evening throughout the year.

Other persons also spoke of the large consumption of this shellfish by the working classes in Belfast and of the rapidity with which stocks of the food were disposed of in the streets, even very young children purchasing them in exchange for rags and so on. Moreover, the Commission were also told that over and above this professional trade, many persons gathered the shellfish from the shores of the Lough for their own consumption.

* Returns published by the Belfast Harbour Commissioners state that the export of shellfish and mussels from Belfast amounted to 382 tons in 1905, to 461 tons in 1906, and to 466 in 1907.

There can be no doubt, therefore, that the consumption of periwinkles, mussels and cockles, particularly the latter, by the working classes in Belfast, has been very large; a matter not to be wondered at, indeed, in the circumstances, seeing that they are so near at hand and so abundant, that they can be obtained from gathering grounds without licence or restriction, and that they are a very cheap article of food.

Cockles and probably mussels also nearly always eaten raw in Belfast.

Moreover, the manner in which these shellfish are eaten in Belfast is important. It appears that periwinkles are almost invariably cooked before sale, but that mussels and cockles are sold uncooked and are almost invariably eaten raw, as oysters usually are. There can thus be no chance of destruction of any micro-organisms that may be in the cockles and mussels, such as may be brought about by cooking.

Shellfish gathered from Belfast Lough exposed to gross sewage contamination.

It is important, therefore, to consider the second question, namely, whether these shellfish are liable to contamination by human excremental matter. Anyone who is familiar with the conditions of the head of Belfast Lough, from which the shellfish in question are gathered, cannot doubt that they are liable to such contamination, or, indeed, that they must have been so liable probably ever since the time when population first settled on the shores of the Lough. From the brief topographical description of Belfast which has been given in our Report, it will be gathered that the Lough forms the sole drainage outlet not only to the watershed of the River Lagan but also to the shores of the Lough on either side, and that it has necessarily provided the only receptacle for the sewage of Belfast and of the scattered communities on its shores, ever since Belfast and those communities have been there. And such is the case at the present time. Not only does all the sewage of Belfast find its way into the Lough, but also that of such places, to mention some near its head, as Greencastle, Whitehouse, and Whiteabbey on the northern (Antrim) shore, and Sydenham, Tillysburn, Holywood, and Cultra on the southern (Down) shore.

Moreover, it is to be borne in mind that the very features of the head of this arm of the sea, particularly its immense area of foreshores, are probably an outcome of the topography referred to above, the foreshores having been formed largely as result of the washing down of alluvial matters and mud from the Lagan and tributary streams. Consequently, it may be inferred that there is a natural tendency for solid matters, which would include, of course, those contained in sewage discharged into these streams, to pass to and to accumulate specially on these foreshore areas or "slob lands," as they are locally termed. It is from these foreshore areas on both sides of the Lough, or those portions of them which are readily accessible at low water, that the shellfish in question are obtained.

The tidal currents at the head of this Lough are extremely sluggish, and Professor Letts has expressed the opinion as result of his own experiments, that there is a zone of permanent pollution involving the head waters over an area extending some $3\frac{1}{2}$ miles from the mouth of the River Lagan.

It is not surprising, therefore, that there is evidence of serious sewage contamination in the areas from which the shellfish are obtained, as, indeed, the Commission had the opportunity of seeing for themselves. Not only is the sand from which cockles, for instance, are principally gathered, viz., near Greencastle, almost black and evil-smelling, with marked sewage odour, but the shells of the cockles themselves also are deeply stained; while bacteriological evidence of sewage contamination has frequently been found in samples of shellfish gathered from the head of the Lough by all those who have examined them in this way. Professor M'Weeney, Professor Lorrain Smith, and Professor Symmers* have done so on several occasions, with results that have been published in various official reports.

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* Professor Symmers in 1906 found a bacillus in some of these cockles which, in his opinion, was the paratyphoid bacillus.

Shellfish from Belfast Lough undoubted possible agency of fever.

The foregoing considerations make it manifest that in these shellfish under the conditions in which they are grown, gathered, distributed, and, as regards mussels and cockles, eaten uncooked in Belfast, there is undoubtedly a possible agency of fever; and the question arises whether this possible agency has been an important agency, that is to say, whether it can have played a large part in the production or maintenance of fever in Belfast. If it has so played a large part, it is likely that the fact would show itself by some sort of correspondence between the behaviour of fever in Belfast and the opportunities, or lack of opportunities, for the operation of this factor.

It has just been shown, for instance, that, assuming that shellfish have been an important factor, explanation is apparent for the limitation of fever mainly to the working classes, and also for the tendency to undue amount of fever which has been exhibited by Belfast for at least as long a period as the records cover. It is important, therefore, to ascertain whether there are any other facts pointing in the same direction.

Is it possible, for example, to throw light, from the point of view of shellfish, on one of the most striking features in the history of Belfast fever, namely, its large increase during the decennium 1891–1900, and especially during its latter portion from the beginning of 1897 onwards; on that feature, that is to say, which made it so difficult to accept a thesis laying the responsibility on insanitary conditions, and which could not be explained by a thesis implicating the water supply?

Alteration of disposal of sewage in Belfast in 1893.

In order to deal with this question it is necessary to allude once more to the disposal of Belfast sewage. It has been shown in our Report that, prior to the commencement in 1889 of the new main drainage system, the bulk of Belfast sewage was discharged into the River Lagan at various places, with the result that this river was then an evil-smelling stream, owing to the deposit and putrefaction of much of the solid matters of the sewage in the river itself before it emptied into the Lough. By the operation of the main drainage system all these discharges of sewage into the Lagan were abolished, except that from some shipbuilding yards, and diverted to one new outfall in the Lough itself.

The actual point of discharge of this new outfall was at the end of a wooden sewer or "shoot," as it is called, stretching about a mile along the foreshore of the Lough from the outfall pumping station, and situated more than $2\frac{1}{2}$ miles seawards from the old principal discharges into the Lagan. The professed object of this long "shoot" was to ensure the discharge of sewage at a point whence it would flow rapidly into deep water.

This change effected, of course, a radical purification of the River Lagan. Also, it resulted in the direct access to the head waters of the Lough of an enormous volume, estimated now at 15 million gallons a day, of fresh undiluted sewage, together with all its suspended solid matters. Under the superseded arrangement the sewage had been at least diluted by the waters of the river, and largely deprived of its suspended solids by sedimentation in the river before it ultimately reached the Lough at the mouth of the river.

Increased pollution of head of the Lough as result of alteration of sewage disposal

Not only, however, did this change thus greatly increase the direct pollution of the head waters of the Lough, but it also brought the point of discharge of this immense volume of sewage much nearer to the shellfish grounds—within about half a mile, indeed, of the nearest part of the principal cockle grounds, near Greencastle, on the Antrim shore. It seems obvious enough, therefore, that the chances of pollution in serious amount reaching these cockle grounds in particular must have been increased to a very large extent by the changed method of sewage disposal, though it is probable that at the outset they were greatly safeguarded by the operation of the "shoot" which has been referred to.

Shellfish safeguarded at first by operation of "shoot."

There seems to be no reason to doubt that, in accordance with the intention of the designers of the system, the bulk of the sewage, and especially of its suspended solids, at first found its way rapidly into deep water, viz., the "Whitehouse Roads," in a direction away from the cockle beds. This safeguard was probably helped by adherence to a provision of the Belfast Main

Drainage Act which prohibited discharge of sewage from the new outfall into the Lough "except between the commencement of ebb tide and thirty minutes after half ebb tide at the point of discharge."

The breakdown of "shoot"; first ascertained to have occurred early in 1897.

But it was not long before this safeguard disappeared The "shoot" became blocked, and finally broke down in a number of places, with result that sewage, instead of finding its way mainly into deep water as intended, was discharged from breaches in the "shoot," and, as has been indicated in our Report, was distributed, so far at least as regards its suspended solids, mainly along the foreshore on the Antrim side. So much so, indeed, was this the case, that according to the evidence given the level of this foreshore has been materially raised. To aggravate matters, the volume of sewage to be disposed of increased to such an extent that it became admittedly necessary to discharge it into the Lough outside the times permitted by Parliament.

It remains to be added that sewage was first discharged from the new outfall *viâ* the "shoot" into the Lough in October, 1893, and that it first became definitely known early in 1897 that the "shoot" had broken down.

Difficulty of explaining increase of fever in Belfast in 1897 onwards disappears, if shellfish be regarded as an important agency of its spread.

If, therefore, it may be believed, as indeed it seems impossible not to believe, that this changed method of sewage disposal, especially after the breakdown of the "shoot," must have enormously increased the opportunities of gross sewage contamination reaching at least the principal cockle beds on the Antrim shore; and if, at the same time, it be assumed that the consumption of these shellfish was capable of taking an important part in the maintenance of fever in Belfast, it clearly follows from the dates given above that, so far as coincidence in point of time is concerned, the difficulty of explaining the increase of fever in Belfast in the latter portion of the decennium 1891-1900, and especially from 1897 onwards, disappears. To put it inversely, it may be said that the fact that the exceptional increase of fever referred to followed so closely upon the increased opportunities of gross contamination of the principal sources of shellfish by vast volumes of sewage, together with the fact that there is an absence of other adequate explanation of this increase of fever, affords in itself presumption that Lough shellfish did take an important part in the maintenance of fever in Belfast.

It thus appears possible to explain three important features of the Belfast fever by the influence of shellfish derived from Belfast Lough without being inconsistent with the facts—namely, the tendency exhibited by Belfast to excess of fever year after year for very many years; the limitation of that fever, at least since notification commenced, principally to the working classes; and the increase of that fever in the later years of the 1891-1900 decennium.

It is clearly important, therefore, to ascertain if there are any other facts confirmatory of this chain of presumptive evidence.

Similarity of the behaviour of the disease in various districts likewise explicable

As to this it cannot fail to be recognised that what has been shown to be one of the most essential features of Belfast fever since 1897, and one hitherto difficult of explanation, namely, the broad similarity and simultaneity in each year of the behaviour of the disease in diverse parts of the city, presents no difficulty at all in connection with shellfish. It is, in fact, precisely in accordance with what might have been expected.

Likewise decrease of fever since 1901.

Question may next arise whether another important feature of Belfast fever, namely, its diminution since 1901, can be accounted for from the point of view of shellfish. There seems to be no doubt that the sale of shellfish, and particularly that of cockles obtained from the beds at Greencastle, has greatly diminished in Belfast in recent years Thus, a witness informed the Commission that whereas twenty or more professional gatherers had been engaged daily in collecting cockles at Greencastle for sale, he now knew of not more than three who were still so engaged. Other witnesses spoke also to the same effect.

It appears that in 1902, owing doubtless to a suspicion that Lough shellfish had played some part during the prevalence of fever in Belfast in 1901 and

previous years, the Corporation began to take steps, by means of warning notices displayed upon the foreshores, to indicate that the shellfish there were unwholesome. More recently the Corporation's officers have from time to time seized, and threatened to seize, stocks of shellfish offered for sale in the city, which indicated from their appearance that they had been exposed to gross sewage contamination. It may be almost suspected, too, that the very appearance of the shells of the Greencastle cockles, almost coal-black as they are, must have led to a diminished sale of them, amongst at least the older members of the community.

It is probable, therefore, that there has actually been a diminished consumption of Lough shellfish by the population of Belfast in recent years. Although no interference has been possible to prevent persons from gathering shellfish from the foreshores for their own use, and, as a matter of fact, many persons do still so collect cockles even at Greencastle, there can be little doubt that a diminution in their systematic distribution through the streets on sale must have had a great effect on the total amount consumed by the population. Nevertheless, it is also probable that the total consumption is still considerable.

Consequently, from the point of view of Lough shellfish, not only is it not difficult to account for the diminution of fever in Belfast since 1901, but also it becomes possible to account for the undue amount of fever which still remains.

There is, however, another question in connection with this diminution of fever since 1901, and it arises from a consideration of the fact that 1901 was the fifth year in succession in which there had been an excess of fever abnormal even for Belfast. For this suggests the view that, after so long a period of such abnormal excess, there may have been but little susceptible material left in the population for further serious attack by fever, especially as only a limited section of the population appears to have been open to attack. This view is strengthened when it is recalled that, as shown in our Report, there is reason to believe that about this time the population of Belfast was relatively stagnant or even perhaps diminishing to some extent. There seems to be no doubt at least that less susceptible material was being newly added to the population about 1901 and succeeding years than must have been the case, for instance, in 1898. Moreover, this relative stagnation of the population seems to have applied particularly to the working classes which the fever was almost exclusively attacking *

If it may be believed, therefore, that a relative insusceptibility of the population to fever could have been brought about by the quinquennium of very excessive fever, this may have been an important factor in the reduction of fever since 1901. In this event, it seems clear that the effect of this would show itself more particularly in the first few years after that date —at a time, that is, when perhaps it might be questioned whether any important diminution in the consumption of Lough shellfish had yet taken place.

It has now been shown that the principal features of the history of fever in Belfast, namely, its excess for at least 30 years; its limitation in the main to the working classes; its similar and simultaneous behaviour in widely separated parts of the city; its great increase in the latter half of 1891-1900; its diminution since 1901; and, lastly, its remaining in undue amount even now in spite of important sanitary improvements, are all alike consistent with a thesis that Lough shellfish have played an important part in the production and maintenance of that fever. It may next be considered whether any subsidiary features of that history are likewise consistent or not with such a thesis.

The increase of fever in 1889

For instance, the increase of fever mortality which occurred in 1889, and to which Professor Lorrain Smith directed so much attention, deserves consideration. It has already been noted that it is probable that it is not the increase of fever mortality which began in that year which requires explanation, so much as the diminution which preceded it in the early eighties, as may be seen by referring to the first part of Table II. But in either case

* Thus, according to figures supplied by Mr. Munce, Assistant Surveyor to the Corporation (p. 1988, Minutes of Evidence), the number of artisans' new houses erected in Belfast in the years 1896 to 1901 were 941, 1,207, 1,179, 947, and 548 respectively, an average of 964 per year; while in the years 1902 to 1906 the numbers were 195, 151, 130, 75, and 126 respectively, an average of only 135 per year.

it is obviously not an easy task to find adequate explanation of a fall or rise which occurred some 20 years ago or more, and especially so in the case of an assumed agency of fever of the nature of shellfish. Even if it were unquestionable that shellfish was operating as the predominant factor in the maintenance of fever in a given community, it would be impossible to foretell to what extent in any given year that fever would prevail. The matter does not admit of mathematical calculation, since it must be largely dependent on a diversity of subsidiary factors, such as tides, currents, temperature, wind, and other climatic conditions, susceptibility to fever, and so forth. It certainly does not follow that absence of adequate explanation of the diminution of fever so long ago as the early eighties, and of its subsequent rise in 1889, necessarily shows that such fall and rise were, in fact, inconsistent with a shellfish thesis.

Nevertheless, in this particular instance there seem to be some facts from the shellfish point of view which do help to suggest explanation of this fall and rise. For instance, the Commission were informed that in the early eighties there was considerable interference with the trade of shellfish gathering, owing to the reclamation of a large area of foreshore, so much so that many of the gatherers lost their employment and claimed compensation; with result, no doubt, that for a time less Lough shellfish was sold in Belfast. It would appear that in those days shellfish were collected for sale nearer Belfast than Greencastle, in the neighbourhood in fact of the situation of the present outfall pumping station. The rise of fever mortality in 1889, on the other hand, may have been due, as Table II. indicates, to a reversion to the conditions which prevailed before the fall of fever mortality set in. It is at least suggestive that the dispossessed shellfish gatherers are said to have regained their trade by going to Greencastle to collect their cockles, and that the number of sewers discharging upon the foreshore near Greencastle is said to have been increased about this time.*

Another subsidiary feature may be considered. It has been shown that, the distribution of fever since 1897 has corresponded broadly with that of shellfish in the city, in that both corresponded with the distribution of the working classes; but it will be observed, on reference to the 1898 "spot maps," that there is evidence of the disease tending to form three principal groups—one in the neighbourhood known as Ballymacarrett (No. 12 district), another in the neighbourhood of Grosvenor Road, and a third in the area lying between Crumlin Road and Falls Road. In this connection it is of interest to note that the Commission were informed that the principal districts in Belfast in which cockles were hawked for sale every evening were Ballymacarrett, the Smithfield district, and the Crumlin Road area. This reveals a singularly close correspondence with the main fever groups referred to.

Parts of city most affected by fever where shellfish mostly sold.

There are other circumstances in connection with Belfast fever which become easy of explanation if it be assumed that shellfish was an important factor. Thus the difference between the incidence of fever on the two Stonyford areas of water supply before Mourne water came into the city is easy of explanation in this way, since the western of these areas, or rather that part of it which was heavily invaded with fever, is almost entirely inhabited by the working classes, while the eastern area is very largely residential. Moreover, the differences between the incidence of fever on the various sections of the Woodburn area of supply are probably explicable in the same way. The appearance, too, of fever in the outlying district of Ligouiel, both in 1898 when the water supply was derived from local wells, and in 1901 when the water supply was derived from Woodburn, likewise becomes easy of explanation.†

Subsidiary features of Belfast fever explicable by influence of shellfish.

Furthermore, the immunity enjoyed by persons in institutions and by the residential neighbourhoods can also be explained in the same way. Lastly, the immunity from fever which appears to have been enjoyed by Jews in Belfast can also be accounted for in this way. This was pointed out by Sir

Immunity of the Jewish community.

* It is also suggestive that it was during 1889, that a temporary outfall for the bulk of Belfast sewage came into operation near the head of the Lough, pending the completion of the new outfall referred to on page 135.

† As to this district it is to be noted that fever has diminished there as elsewhere in the city, and this notwithstanding the fact that little or no reduction of privies has been effected there, also that the hawking of cockles used to prevail there and has practically ceased now.

Otto Jaffé, ex-Lord Mayor of the City, in a letter to the medical press in 1902, in which he attributed this immunity to the Jewish prohibition of shellfish as an article of food. The immunity of the Jews has, it appears, been complete, so far as inquiries made by this gentleman can establish such a matter, with one exception, namely, when in 1906 some cases occurred in connection with the Windsor milk outbreak. On the other hand, it is true that the Jewish community in Belfast is a very small one, comprising not more than 700–800 persons. Nevertheless the majority of these are said to belong to the working class, and when it is borne in mind that in 1898 nearly 2 per cent. of the total population of Belfast were attacked by fever, and that the proportion of attacks among the working class population only must have been still higher, it seems probable that the immunity of the Jews in that year at least was an improbability in the absence of special reason. At the same time it is not suggested that this immunity of the Jews, in view of their small numbers in Belfast, is more than confirmatory of other evidence.

Seasonal incidence of fever.

It is manifest also that what is known of the seasonal incidence of fever on Belfast is not inconsistent with the shellfish hypothesis. The diagrams clearly indicate that, for the most part and especially before 1902, there was marked tendency of Belfast fever to increase in the warmer months and to diminish in the colder months of the year. Although there is evidence that in the nineties Lough shellfish were hawked in the streets throughout the year, it is but reasonable to suppose that larger quantities of this food were obtained and consumed in the warmer months than in the colder months. Nevertheless, as will appear later, the influence of shellfish was by no means confined to the warmer months.

Shellfish probably the controlling factor of Belfast fever.

Seemingly, then, not only the principal features of the history of Belfast fever, but also many of its subsidiary features are either capable of explanation by or are not inconsistent with a hypothesis that Lough shellfish have taken an important part in inducing fever in Belfast. It may be convenient to recapitulate those features of Belfast fever which are thus not inconsistent with the shellfish hypothesis. They are as follows :—

1. The excess of fever for as long a period as the records of fever mortality cover.
2. The absence of relation between the distribution of water and the distribution of fever.
3. The similarity and simultaneity of the behaviour of fever in various sections of the city, irrespective of water supply, and in spite of a diversity of local conditions.
4. The great increase of fever in the latter half of the decennium 1891-1900.
5. The diminution of fever since the end of 1901.
6. The undue amount of fever which, nevertheless, still remains.
7. The limitation of fever mainly to the working classes, according to the data obtainable since 1897.
8. The diminution of fever mortality in the early eighties.
9. The increase of fever mortality which began in 1889.
10. The grouping of the main fever areas in the city.
11. The difference between the incidence of fever in the eastern and western Stoneyford areas of water supply, as well as, probably, the differences between the incidence of fever in the various sections of the Woodburn area of supply.
12. The incidence of fever on Ligoniel alike with water derived from local surface wells and with water supplied from Woodburn.
13. The immunity from fever said to have been enjoyed by persons resident in public institutions.
14. The immunity from fever said to have been enjoyed by the Jewish community.
15. The "seasonal" behaviour of fever.

There is thus a very large accumulation of presumptive evidence in support of the shellfish hypothesis, and it seems impossible, therefore, not to conclude that Lough shellfish have been, as matter of fact, a very important factor indeed in the production and maintenance of fever in Belfast.

The facts seem to indicate more than this, however. It has to be borne in mind that the foregoing features of Belfast fever are not only not inconsistent with the shellfish hypothesis, but also that, as has been shown, many of them are inconsistent either with a theory which attributes the fever to the water supply, or with a theory which attributes it to the influence of insanitary conditions.

In other words, the shellfish hypothesis seems to be the only available one which sufficiently fits the known facts. In these circumstances it seems difficult to avoid the conclusion that the main and minor features of Belfast fever have been established specifically as result of the influence of Lough shellfish; that, therefore, shellfish have been not only a very important agency of fever, but also that this agency has been able, to a great extent, to constitute itself the controlling or governing factor of the excessive fever of Belfast.*

It has long been suspected that the consumption of Lough shellfish has been directly responsible for many cases of fever in Belfast. Dr. Whittaker, the ex-Medical Superintendent Officer of Health, reported in this sense not infrequently, and Dr. Browne, one of the Medical Inspectors of the Local Government Board for Ireland, alludes to this suspicion in his reference to Belfast Lough in his official report on "Shellfish Layings on the Irish Coast." Moreover, in 1906 a special investigation was made by Mr. Reynolds, one of the sanitary sub-officers of the Corporation, regarding a certain group of cases of fever—22 in all—which occurred in February and March of that year, and as a result he ascertained in 15 of these cases a definite history of recent consumption of cockles, and in others a doubtful history.

In this connection it has to be noted that there are many difficulties in the way of obtaining information on this point. The patient, for instance, may be too young to give the necessary information; he may be too ill; or he may have been removed to hospital; but apart from these obvious difficulties it has also to be borne in mind that when the consumption of a given article of food becomes common or even more or less habitual, such as may well have been the case with shellfish in Belfast, little recollection is likely to be had of a particular meal of such food when inquiries come to be made; especially when, as is usually the case where enteric fever is concerned, such inquiries come to be made after not less than three or four weeks or more have elapsed since the suspected meal was partaken of.

Although, therefore, it is extremely probable that many more attacks of fever in Belfast have been directly caused by the ingestion of Lough shellfish than has been suspected, it is quite clear that all, or even nearly all, the attacks of fever, which have occurred there, cannot have been due directly to this cause. Had they been so, it is difficult to believe that it would not have been discovered long ago. In spite of the defects in the sources of information which have been alluded to, and of the fact that the impression regarding the responsibility of the water service tended to obscure other interpretations of the evidence, anything like a universal, or almost universal, direct connection between Lough shellfish and enteric fever would have become too obvious to be overlooked.

Shellfish not responsible for all cases of fever in Belfast.

*It is of interest to note that in those portions of the Belfast Registration District which are outside the city, and which adjoin the foreshores of Belfast Lough, fever appears also to have been excessive.

Notification of infectious disease has not been in force in these areas until quite lately, but the data given in the Registrar-General's quarterly mortality returns show that both in district No. 7, which extends along the northern (Antrim) shore of the Lough, and includes Whiteabbey, part of Greencastle, &c., and in district Castlereagh No. 2, which extends along the southern (Down) shore, and includes Holywood, the mean annual death-rate from enteric fever and simple continued fever during the decennium 1891-1900 was about ·30 per 1000. This is a very high fever death-rate for such scattered and largely residential districts as these are, and it is highly probable, moreover, that it is understated. The quarterly mortality returns in question are not corrected for deaths in institutions; that is to say, deaths of persons belonging to these districts which may have occurred from fever in institutions inside Belfast, are not included in them. The water supply of these districts is different from that of Belfast.

The correct interpretation of the indication of the chain of presumptive evidence in this case appears to be that not only have Lough shellfish been the "additional fever agency," referred to on page 113, in the discussion of the influence of insanitary conditions in relation to Belfast fever, but also that this "additional" fever agency has been the means of keeping the disease constantly "alive," as it were, in Belfast; not necessarily in the sense that it has been the direct cause of a greater number of cases than all other agencies put together, but in the sense that it has largely controlled the course of events, by furnishing repeated opportunities for these other agencies to come into operation, and that it has thus given to the history of Belfast fever its chief characteristics.

In other words, the inference to be drawn from the facts appears to be that if this shellfish agency had been absent, the history of fever in Belfast would have been vastly different from what it has been. Instead of this history having been unique, it would have, at the least, approximated that of other towns in the United Kingdom. On the other hand, if the operation of all other agencies of fever could by any possibility have been annulled, and the shellfish agency left alone in operation, the amount of fever in Belfast would also have been much less, although in this hypothetical event the chief characteristics of its history would have remained the same, except as regards amount.

Subordinate factors at work.

The experience of water epidemics may serve to make this point clear. Even in the most explosive of these very many cases occur which cannot be explained adequately by attributing them to the original source of infection. These cases, known as "secondary" cases, occur in the later stages of these prevalences, and their occurrence serves to cause the decline of such prevalences to be much more gradual than their rise to a maximum. This gradual decline is a common feature of these explosive outbreaks, and is well exemplified in the diagram showing the behaviour of the disease at Worthing, Maidstone, and Lincoln (see Diagram 1.).

It may be imagined that something analogous to this has occurred, over and over again, in Belfast—that there have been many cases due directly to infection by Lough shellfish, and also numerous cases due to secondary causes of infection, and again, maybe, other cases due, in turn, indirectly to the effect of these "secondary" cases, and so on in cumulative fashion. But since these cases would not have occurred in the absence of the original agency of fever, just as the secondary cases of a water epidemic would not have occurred in the absence of the epidemic, so it may be said that the original agency of fever is the governing factor in the matter.

In the production of secondary cases in Belfast several agencies have, no doubt, taken part, such as personal infection, occasional infection of individual milk supplies, possibly, also, the insuction of infecting material into water mains and service pipes, and, above all, probably, insanitary conditions, using this term in its widest sense. Indeed, it may be surmised that with an agency of fever like shellfish repeatedly in operation—day after day, at times, as it must have been in Belfast—all "insanitary conditions" must have been provided with every opportunity to operate to the full in fostering the disease, whether they were privies, or defective scavenging of refuse from houses, or storing of such refuse in the centre of the city, or defective paving of back yards and passages, or defective drains, or defective sewers leading to their engorgement and "flooding" from time to time, or whether they were the uncleanly habits of the people themselves, or the defective sanitary administration, as result of which many cases of enteric fever and of continued fever were allowed to be treated at home.

It might be said, of course, that a conclusion such as the foregoing is open to question on the ground that it credits shellfish with a power of disseminating disease greater than has been accorded to it elsewhere. Probably this is true, although it is a fact that for some years suspicion has grown in many places that shellfish may be a much more important factor in the maintenance of enteric fever than had at one time been supposed.

It is noteworthy that one of these places is Dublin, whose experience of enteric fever more nearly approaches that of Belfast than any other large city in the United Kingdom. The following are extracts from a Report on the "Sanitary Circumstances and Administration of the City of Dublin," made by Surgeon-Colonel Flinn in 1906 :—

"It is a question as to the part that shellfish (oysters, cockles, mussels) may have in former years played as one of the causes of enteric fever in Dublin. Shellfish gathered from polluted sources, such as existed, and still exist, in the vicinity of Dublin must be regarded with suspicion, and it seems probable that the ingestion of shellfish from these tainted sources has played no inconsiderable part in the history of enteric fever in Dublin, ... From inquiries that I have made there is but little doubt that cases of enteric fever have occurred, and do occur, in Dublin, due to the eating of oysters and shellfish gathered from polluted areas, but no precise and accurate information is available on this point. Cockles are gathered in very large quantities in the vicinity of Dublin, and a great number of people earn a livelihood by hawking and selling them in the poorer quarters of the city. At low water during the spring, summer, and autumn months, the strands on the southern shores of Dublin Bay are sometimes thickly crowded with cockle gatherers. It is difficult to ascertain accurately the amount of cockles consumed in Dublin, it is, however, well known that cockles are very largely eaten all the year round in the city, particularly in the summer and autumn months, by the poorer classes. I can only arrive at an approximate estimate of the amount from information that I have received. It is probable that from about fifty to fifty-five thousand quarts of cockles, and probably more, are eaten in Dublin annually.

On the other hand, the fact that the presumptive evidence in Belfast points so strongly, as it does, to the capability of shellfish to act as the governing factor in promoting undue maintenance of fever, may be a matter of great practical importance outside Belfast.

Nevertheless, it needs but little consideration to perceive that in the case of Belfast the circumstances which have led to this exceptional conclusion, if such it be, are themselves very exceptional, involving as they do the following combination :— Exceptional combination of circumstances favouring influence of shellfish in Belfast.

1. A great city of nearly 400,000 persons comprising a very large proportion of the working classes.

2. The existence of a superabundance of an article of food, popular with the working classes, at the very doors, as it were, of this great population ; and the possibility of obtaining this food, at little or no cost, and with little or no trouble, owing to the easy accessibility of its sources to both professional and private gatherers, without restriction of any kind.

3. The daily discharge of immense volumes of fresh, crude sewage from a single outfall into a shallow sluggish arm of the sea, in the immediate vicinity of the sources of this food.

4. The consumption of this food uncooked.

It is questionable whether a parallel so favourable to the influence of shellfish in producing enteric fever, can be found of this combination of circumstances anywhere in the United Kingdom or, indeed, anywhere else. It can hardly occasion surprise if in such circumstances as these the consumption of the food in question has caused disease on an extensive scale : it would be occasion for wonder if it had not done so.

There is obviously good reason in this case, therefore, not to reject a conclusion simply because it involves acceptance of an agency of fever which has usually been regarded as a contributory rather than as a dominant factor. On the contrary, the very fact that the available evidence points to a relationship between a manifestation of disease so exceptional that, as pointed out at the outset of this addendum, it has no parallel in the United Kingdom, and a combination of circumstances, likewise seemingly unique, is itself an indication that the trend of that evidence is not far wrong.

L. W. DARRA MAIR.

APPENDICES.

LONDON, 15*th April*, 1907.

THIRD REPORT BY DOCTORS HOUSTON AND GORDON ON THE QUALITY OF THE BELFAST WATER SUPPLY.

In our first report we dealt chiefly with (1) the results of our topographical inspection of the gathering grounds of supply; (2) the negative results of comparisons made between Professor Symmers' microbes and the typhoid bacillus; and (3) our inability, after careful search, to find the typhoid bacillus in the Belfast filtered water.

In our second report we gave, together with our conclusions, the detailed results of our bacteriological tests of the quality of the sources of supply, and of the water both before and after filtration, and also of the water as actually delivered to consumers.

In this our third report we give the result of our detailed comparison of Professor Symmers' microbes with B. typhosus, B. enteritidis (Gärtner), and B. faecalis alkaligenes, respectively.

That we are unable finally to associate Professor Symmers' microbes with any of the above-named micro-organisms will be apparent from the divergency in their characters, as recorded in the diagram accompanying this report, hut we may supplement that tabular statement with observations as follows :—

To associate a microbe causally with disease in man, or to infer relationship between one microbe known to be definitely pathogenic to human beings, and another microbe unknown in this respect, on the basis of the agglutination test *per se* is not justifiable (see Appendix), unless merely by way of tentative warning pending the results of a more complete investigation.

Nor can such causal association be accepted, even though a certain number of the tests, besides the agglutination test, may lend support to the hypothesis of pathogenicity.

Unless a suspected microbe conforms absolutely to all the available tests for microbes known to be pathogenic to human beings, its ultimate significance in relation to disease depends solely on the nature of the evidence why it should be regarded either as a true example of known pathogenic micro-organisms, or as a new species of pathogenic microbe hitherto unrecognised

It is obvious that this evidence must be of a most convincing kind to warrant its acceptance.

It is not difficult to isolate microbes from non-pathogenic sources which will be agglutinated to some extent by the sera of either normal or diseased individuals, or of animals immunised with specific microbes. Though the degree of the response is less, bacteria belonging to the same group are liable to be agglutinated to a certain degree by the sera of animals immunised against other iudividuals of that group; this general reaction being known as the "group reaction."

It is also easy to isolate microbes from pure or relatively pure sources, which, by reason of their negative characters, simulate certain pathogenic bacteria.

Professor Symmers' microbes belong to an interesting class which, both as regards agglutination, and in respect of negative attributes, simulate, to some extent, microbes known definitely to be pathogenic.

We found that Professor Symmers' microbes were agglutinated in comparatively low dilutions of the serum of an animal immunised against the typhoid bacillus, while this same serum agglutinated the typhoid bacillus in high dilutions.

They also yielded negative results with a number of tests to which B. typhosus gives a negative response. But by the sum of their characters, positive and negative, we had no difficulty in finally differentiating them from the bacillus of typhoid fever. Although we regard Professor Symmers' microbes as of considerable scientific interest, therefore, we cannot on the present evidence, associate them with a pathogenic role, or as specially significant of dangerous pollution. (See Appendix 2). Indeed they seem to us less important in the latter sense than B. coli.

The B. coli test, it must be remembered, has been found both in this country and elsewhere to be the best available index of the presence of excremental pollution. Moreover, by its use the bacteriologist is enabled to measure with reasonable accuracy the *degree* of excremental pollution of water. Whenever practicable, however, the interpretation of the results of the B. coli test, or of any other test of excremental pollution, should be influenced by the results of topographical inspection.

In conclusion, we consider that proof of the significance of a suspected microbe depends on fulfilment of the *sum* of characters possessed by the pathogenic microbe with which it suggests relationship, and that any weakness in the chain of evidence should invalidate its claims to kinship or identity unless accompanied by overruling evidence of a most convincing kind.

A. C. HOUSTON.
M. H. GORDON.

April 15th, 1907.

Biological Attributes of B. Typhosus; B. Gartner (A); Symmers' Microbe; B. Coli; and B. Faecalis Alkaligenes (Kral).

Description of Microbe.	2 % peptone tinted with litmus + 1 % sugar (2 days at 37° C).														Proskauer and Capaldi's Tests (24 hours at 37° C).		Growth on Potato.	Broth Cultures.	Peptone Water Cultures.	Indol Test Peptone Water.	Neutral Red Broth Cultures.	Litmus Milk Cultures.	Oblique Gelatine Cultures.	Motility.	Remarks
	Rhamnose.	Glucose.	Lævulose.	Galactose.	Maltose.	Saccharose.	Lactose.	Raffinose.	Inulin.	Dextrin.	Salicin.	Glycol.	Glycerine.	Mannite.	Dulcite.	No. 1.	No. 2.									
B. Typhosus.	No Change	Acid				No Change				Bleached	No Change		Bleached	Acid	No Change	No Visible Growth	Distinct Acid	Transparent Colourless	Uniform Turbidity		Neg	No Fluorescence	Slight Acid No Clot	White Film	Very Motile	
B. Gartner (A).	Acid and Gas					No Change				Bleached	No Change		Bleached	Acid and Gas		Growth Acid	Bleached look	Semi-transparent Growth	Uniform Turbidity		Neg	Fluorescence	Acid than Alkali	White Film	Very Motile	
Symmers' Falls 1.	NO CHANGE																	Fawn Coloured	Feeble Growth no Scum	Better Growth no Scum.		Neg	Feeble Growth no Fluor	Strong Alkali	White Film	Very Motile	
Symmers' Falls 2.	NO CHANGE																	Fawn Coloured	Feeble Growth no Scum	Better Growth no Scum		Neg	Feeble Growth no Fluor	Strong Alkali	White Film	Very Motile	
Symmers' Grosvenor 1	No Change	Bleached look	NO CHANGE							Bleached look	NO CHANGE							No Visible Growth	? No Growth	Uniform Turbidity		Neg	? No Growth	Slight Alkali	Filmy Growth	Very Motile	
Symmers' Grosvenor 2	No Change	Bleached look	No Change	? Bleached	NO CHANGE			? Bleached		Bleached look	No Change.		Bleached look	? Bleached		No Change		No Visible Growth	? No Growth	Uniform Turbidity	? Faint Trace	Neg	? No Growth	No Change	? Slow Liquefier	Very Motile	
B. Coli (from Water).	ACID AND GAS								No Change	Bleached ? Gas	Acid Slight Gas	No Change	Acid and Gas		No Change	Growth Acid	No Definite Acidity	Creamy Growth	Uniform Turbidity.		Pos	Fluorescence	Acid and Clot.	White Film	Very Motile	
B. Faecalis Alkaligenes (Kral).	No Change	? Slight Acid	NO CHANGE													? Alkali	No Definite Acidity	Fawn Coloured Growth	Well Marked Scum		Neg	No Fluor	Strong Alkali	Characteristic Growth	Very Motile	

The agglutination reactions of Professor Symmers' microbes differed from those of B. typhosus in degree, and they proved to be non pathogenic when injected intra-peritoneally in large dose into rodents.

APPENDIX I.

Extract from Dr. Rudolf Abel's *Bakteriologisches Taschenbuch* (10th Edition).

The Widal serum reaction has numerous sources of error, more especially the following:—

(*a*) The serum of persons who have had typhoid months or years before, but who at the time being may have another disease, can agglutinate B. typhosus.

The serum of icterus cases also often agglutinates B. typhosus in high dilution.

(*b*) The agglutinating capacity of the serum may not develop in the usual time, and sometimes it does not appear at all. When a negative result as regards agglutination occurs in a case in which, on clinical grounds, there is a suspicion of typhoid infection, it is recommended that the test should be repeated after an interval of a few days.

(*c*) In typhoid infection the blood serum possesses a capacity of agglutinating paratyphoid bacilli and *vice versa*.

In doubtful cases, therefore, it is advisable to test agglutination of high dilutions, such as 1 : 100, 1 : 200, 1 : 500, etc., against both B. typhosus and B paratyphosus. The bacillus causing the disease is agglutinated by a higher dilution than the others which are responding to what is known as the "group reaction."

As support for the clinical diagnosis, Widal's reaction possesses great value when correctly interpreted. Therapeutically, and from the point of view of sanitary administration, both typhoid and paratyphoid are treated similarly.

One should never confine oneself to the statement that Widal's reaction is positive, but should also state the kind of test applied (tube or cover glass), the dilution in which the serum is effective, the time within which agglutination takes place, and the intensity of the reaction (complete agglutination), &c.

APPENDIX II.

Copies of Professor Symmers' Reports on Water Samples to Dr. H. W. Bailie.

February 13th, 1907.

I beg to report that samples of tap water from 95 Grosvenor Road and from 259 Falls Road have been examined in this Laboratory during the past ten days. I have to inform you that this water contains, in each case, a micro-organism in every particular identical with the Bacillus of typhoid fever, so far as I have been able to investigate the cultures. In view of the importance of this finding, I am proceeding in my examination of this bacillus in order to establish its exact identity; but, in the meantime, I consider that the water in question must be regarded with the very gravest suspicion.

I am, &c., &c.,

February 15th, 1907.

The bacilli reported upon as being like typhoid, as far as examined, show on continued examination peculiarities that differ somewhat from typical typhoid bacilli. I shall inform you of the result of further investigations.

I am, &c., &c.,

February 18th, 1907

The suspicious organisms from the houses in Falls Road and Grosvenor Road which I reported to you as being identical with typhoid bacilli so far as I had then examined them, have now received more detailed examination. They are not typical typhoid bacilli, but are closely allied to these, being intermediate between colon and typhoid bacilli, with affinities closer to typhoid than to colon bacilli. I regard water containing such organisms as highly dangerous.

Yours, &c., &c.,

London, 22*nd April*, 1907.

FIFTH REPORT ON THE QUALITY OF THE BELFAST WATER SUPPLY WITH SPECIAL REFERENCE TO PROFESSOR LORRAIN SMITH'S REPORTS, BY DOCTORS HOUSTON AND GORDON.

In a report on the epidemic of Typhoid Fever in Belfast, 1898, Professor Lorrain Smith states his conclusions, as follows (page 4) :—

> "Short of discovering in the water the typhoid bacillus also, and thereby giving absolute proof regarding the primary cause of the epidemic, I know of no stronger bacteriological evidence than that which I have adduced in favour of the conclusion that this contamination of the water is one of the causes of the outbreak of the disease in Belfast."

The nature of the bacteriological evidence on which he bases these conclusions is summed up by Dr. Lorrain Smith in a paragraph immediately preceding the one just quoted in the following words :—

> "The general result of my investigation therefore is (1) in the presence in the water of the typical bacilli of the coli-communis group we found evidence of contamination with intestinal excreta. (2) Certain of these bacilli exhibited their relationship to the process of infection in typhoid fever (a) by their lethal effect on small animals (b) by showing the reaction of infection when exposed to the blood of typhoid patients."

We are in agreement in the abstract with Dr. Lorrain Smith's first proposition, viz.:—that the presence of typical B. coli is evidence of the presence of faecal contamination in water although we note that on page 12 of the same report the following apparently contradictory statement in reference to the significance of B. coli is made by him.

> "They (B. coli communis) have, further, been found in water which was otherwise quite pure, and have not therefore been regarded as necessarily a sign of impurity."

Our fourth report to the Water Commissioners contains a series of comparative tables showing the bacteriological quality of water as delivered to consumers in 27 large towns in the United Kingdom including Belfast, and the results indicate that although objection, in the abstract, may be raised to the presence of a single B. coli in even a relatively large volume of water it would be a serious step in practice to condemn drinking water unless on a *quantitative* basis.

The *quantitative* aspect of the question in relation to the last twelve samples of Belfast water that we examined may be expressed by saying that 7 out of the 12 samples examined yielded *negative* results with a test capable of detecting so infinitesimal an amount of pollution as would be produced by adding 1 gallon of sewage to 10 million gallons of water.

In the light of knowledge obtained since the date of Dr. Lorrain Smith's report we cannot accept his second proposition that (*a*) by their lethal effect on small animals, and (*b*) by showing the *reaction of infection* when exposed to the blood of typhoid patients, certain of these bacilli exhibit their relationship to the process of infection in typhoid fever.

As regards the lethal effect on small animals, some years ago we investigated the properties of B. coli isolated from the normal dejecta of healthy persons*

The investigation therefore dealt with the attributes of microbes to which no special pathogenic role could reasonably be attached.

It was found that broth cultures seeded with an infinitesimal amount of normal human faeces—commonly less than one-millionth part of a gramme—were after incubation found highly virulent to rodents on subcutaneous injection.

Further, nine per cent. of the B. coli isolated in pure culture from the stools killed guinea pigs within two days after injection subcutaneously of 1 c.c. of a broth culture incubated at 37·C for two days. Many more of the B. coli were pathogenic in the sense of causing illness of the inoculated animal. These B. coli, it should be added, were isolated from excessively minute amounts of faeces.

Although the test of virulence may perhaps be usefully employed within certain limits to furnish evidence in support of the presence of pollution of an undesirable nature, to affirm that a lethal effect on rodents is necessarily an exhibition of relationship to the process of infection in man appears to us unwarrantable.

Dr. Lorrain Smith's further point that these bacilli (B. coli communis) exhibited their relationship to the process of infection in tpphoid fever by showing the reaction of infection (the agglutination reaction) when exposed to the blood of typhoid patients is also, we think, open to question. The reaction of infection is, in our opinion, too wide a term to apply to the agglutination reaction, which is only part, and probably not the most important part, of the process by which the body reacts to infection with the typhoid bacillus.

We have pointed out in a previous report that the significance of the agglutination reaction depends entirely on its quantitative and comparative aspects.

As an instance of the necessity of regarding the test in this sense we may revert once more to the B. coli of normal stools. It is noteworthy that about 20 per cent. of these B. coli were found to be agglutinated in varying degree by the blood of healthy persons.

It is imperative to bear in mind that typical B. coli giving all the reactions implied by the term Flaginac is not only present in the excrement of man, but that it is also present in the dejecta of a large number of the lower animals, including sheep and cattle.

To give our arguments a concrete basis we will imagine that the persons whose dejecta were examined in connection with the foregoing investigation of normal stools resided on a gathering ground of a water supply, and that their dejecta passed first into the feeding streams, secondly through the storage reservoirs, and finally escaped the barrier of the filter beds. On this assumption, and provided that no loss of attributes occurred in the process,

* Appendix B., No. 5, Report of the Medical Officer, Local Government Board, 1902–3.

the bacteriologist examining the water as delivered to consumers might readily find that his broth cultures were virulent, that a proportion of the B. coli were even pathogenic, and that a certain number of them were agglutinated with the blood of *healthy* persons.

On these findings he would be justified in inferring that the water supply in question was polluted with excreta either of man or of the lower animals, but he would not be justified in drawing the inference that the water was capable of producing typhoid amongst consumers.

In a subsequent report "On the occurrence of Typhoid Fever in Belfast," 1903, Dr. Lorrain Smith has described the sanitary history of Belfast in relation to typhoid fever at considerable length.

We do not think it is within our province to view the statistical side of Dr. Lorrain Smith's report or the results of his interesting investigations on the relation of soil contamination to the occurrence of typhoid fever. But our own observations, and the information placed at our disposal by the Water Commissioners, do not lead us to endorse Dr. Lorrain Smith's wholesale condemnation of the Woodburn and Stoneyford sources of the Belfast water supply; nor do we think his own facts and investigations justify the part of the following statement which we have italicised;—

> "The Stoneyford area has contained in recent years a source of typhoid infection, which has there remained unaltered during the period of sanitary reform in the city, and *we are compelled to hold it to be the primary cause of the excessive amount of Typhoid which has existed since water from this source was supplied to the citizens.*"

Dr. Lorrain Smith does not, we think, lay sufficient stress on the beneficial effect of prolonged storage and the relatively slow rate of filtration practised at the waterworks, and on other factors which make for safety.

In this connection we desire to call attention to Appendix 1, which deals with the Belfast Waterworks statistics compiled, at our request, by Mr. F. W. McCullough, M.I.C.E.

Without entering into detail we may set out the salient features in tabular form as follows:—

—	Number of days storage in sedimentation reservoirs before filtration.	Average rate of filtration in gallons per square foot per hour.	Number of days storage in service reservoirs.
Stoneyford Supply, ...	300	1·02	7¼
Woodburn Supply, ...	275 for nine months of the year and 202 days for 3 months.	1·19 for nine months of the year and 1·62 for three months.	12 for nine months of the year and 8¾ for three months.
Mourne Supply, ...	—	Not filtered, ...	50 (Mourne supply area.)

We note that milk and shellfish, as sources of typhoid infection, are dealt with very briefly on pages 46-47 of Dr. Lorrain Smith's report and no mention is made apparently of watercress, fried fish, and ice-creams, which in other towns have been implicated as possible or probable infective agencies.

Although we are not directly concerned in implicating any agency as a causal factor of typhoid fever in Belfast we are familiar with the usually impure bacteriological qualities of milk, shell-fish, and watercress, and in this

connection we beg, without further comment to submit reports for the information of the Water Commissioners on the bacteriology of :—

Milk
Shellfish
Watercress.

For the purposes of reference we also submit reports by one or other of us relating to the bacteriology of :—

Air and dust
Sewage
Soil
Water
The excrement of cows and other animals and fish.

We would like to add that quite recent observations by Doctors Andrews and Hurtley on the chemical and biological qualities of sewer air at Hampstead would seem to show that the dangerous qualities of sewer air are perhaps, after all, more real than we had been led to imagine from the work of previous investigations.

A. C. HOUSTON.
M. H. GORDON.

April 22nd, 1907.

London, *April 23rd*, 1907.

SIXTH REPORT BY DOCTORS HOUSTON AND GORDON ON THE QUALITY OF THE BELFAST WATER, WITH SPECIAL REFERENCE TO THE VITALITY THEREIN OF THE TYPHOID BACILLUS.

The following experiments were made to determine the vitality of B. typhosus in Belfast water. With this object samples of the water unsterilised and also after sterilisation were infected with the typhoid bacillus, and its progressive increase or decrease determined at stated intervals.

I.—Duration of Vitality of *B. Typhosus* in the Unsterilised Water.

On March 17th, 1907, four samples of Belfast water, each containing about 700 c.c. were taken. These samples were as follows :—

1. Stoneyford water after storage as passed on to the filters at Forked Bridge
2. Stoneyford water after filtration.
3. Woodburn water after storage as passing on to the filters at Oldpark.
4. Woodburn water after filtration.

These four samples were taken to London, and on the following day the number of bacteria contained by them determined.

The results were as follows :—

No.	Sample.	Bacteria per c.c. in Gelatine at 20–22° C.	Bacteria in Bile Salt Agar at 37° C.
1	Stoneyford Unfiltered, ...	1,270	60
2	„ Filtered, ...	9	Under 10
3	Woodburn Unfiltered, ...	790	50
4	„ Filtered, ...	11	Under 10

0·1 c.c. of the above waters failed to yield B. coli, except in the case of Sample 1 which showed 10 but not 100 B. coli per c.c.

Each of the four bottles containing these waters was then liberally infected with living typhoid bacilli.

The amount of living typhoid culture introduced into each bottle was the same, and amounted approximately to 10,000,000,000. As each bottle contained 700 c.c., therefore, the amount of living typhoid bacilli with which they were infected exceeded ten million per c.c. of the water.

After infection with the typhoid bacillus in this way the four bottles were stored in a well insulated box. A thermometer placed in this box with the water showed that the temperature at which they were kept throughout these experiments varied from 10° C. (50° F.) to 15° C. (59° F.). It should be noted that as the bottles were stored in the dark the bactericidal influence of light was excluded in these observations.

At various intervals each of the bottles were thoroughly shaken and cultures made on bile salt agar and on Drigalski and Conradi's medium and colonies resembling those of typhoid subcultured and examined.

The results are seen in the following table :—

TABLE SHOWING VITALITY OF *B. Typhosus* IN BELFAST WATER.

No.	Sample	Number of Typhoid Bacilli in one c.c. of Water				
		One day of Inoculation (March 15th)	7 days later (March 23)	19th day April 4.	29th day. (April 14)	33rd day (April 18)
1	Stoneyford (unfiltered), ...	Over 10,000,000	100 not 1,000	Under 10	1 not 10	Absent.
2	Do. (filtered), ...	do.	10 not 100	do.	Absent.	Absent.
3	Woodburn (unfiltered), ...	do.	100 not 1,000	do.	1 not 10	1 not 10*
4	Do. (filtered), ...	do.	100 not 1,000	do.	Absent.	Absent

As is usual in such experiments, the diminution shown by B. typhosus was progressive. After a week the numbers had fallen from 10,000,000 per c.c. to between 100 and 1,000. After 18 days there were in all the samples less than 10 typhoid bacilli per c.c., and by the 29th day it was absent in this amount in both filtered waters. By the 33rd day the typhoid bacillus was present in 1 c.c. in the case of one sample—Woodburn unfiltered water. It should be borne in mind that the conditions in these laboratory experiments were in all probability more favourable to the vitality of the typhoid bacillus than would be the case in nature. The dose with which the waters were infected was excessively large, and the unfavourable effect of sunlight was excluded. The experiments recently made in America under conditions more closely approximating to the natural conditions imply that decrease of the typhoid bacillus is much more rapid than under these more artificial laboratory conditions.

With view to defining the decrease of the typhoid bacillus in Belfast water in more detail, parallel experiments to the above have been carried out after removal of bacteria from other samples of the water by passing it through a Pasteur filter.

The conditions in the following experiments, however, were more favourable to the vitality of B. typhosus than those in the preceding experiments where the micro-organisms had to compete with the bacteria normally present in Belfast water.

*Final Note, May 4th, 1907. Further tests, however, made on the 38th, 39th, and 40th day after the inoculation process yielded *negative* results.

2.—Vitality of the *Typhoid Bacillus* in Belfast Water, after being rendered germ-free by Filtration through a Pasteur Filter.

Conditions and Results of Experiments.

(1.) The samples of Belfast water were filtered, in each instance, through a sterile Pasteur Filter, and the filtrate collected in sterile glass stoppered bottles (A, B, C, D, E). 1 c.c. cultures made subsequently from these bottles (A, B, C, D, E) yielded negative results. Bottles A, B, C, D, E contained respectively 164 c.c. of Stoneyford filtered water; 134 c.c of Old Park filtered water; 170 c.c. of Stoneyford filtered water; 168 c.c. of Old Park filtered water; and 144 c.c. of 259 Falls Road tap water.

(2.) A strain of B. typhosus comparatively recently isolated from the blood of a typhoid patient was used for the experiments.

(3.) An oblique agar tube was inoculated with this microbe, and the culture incubated at 37° C. for two days. A large platinum loopful of the resulting growth was transferred to a tube containing some sterile water and an emulsion carefully made.

(4.) The number of living Typhoid bacilli per c.c. of this emulsion was determined.

(5.) Known but varying amounts of this typhoid emulsion were added to the bottles containing the Pasteur filtered water.

(6.) It follows that the number of living Typhoid bacilli introduced into bottles A, B, C, D, E was ascertainable. In point of fact, the numbers were broadly as below:—

Bottle.					
A.	More than	100,000	but less than	1,000,000	per c.c.
B.	„	10,000	„	100,000	„
C	„	1,000	„	10,000	„
D.	„	100	„	1,000	„
E.	„	10	„	100	„

(7.) The stoppered bottles were placed in a dark cupboard, and the daily maximum and minimum temperatures of the air in the cupboard noted (see Table 1).

(8.) The number of living Typhoid bacilli in the bottles was determined from time to time. For this purpose the decimal mode of dilution was employed; the cultures from the various dilutions being made in broth. Confirmatory cultures, whenever necessary, were made from the broth on bile-salt neutral red agar, and from this latter medium into other special media (*e.g.*, Proskauer and Capaldi's No. 1 and No. 2).

(9.) For the sake of simplicity the intermediate testings, which were very numerous, are not recorded; but only those in which a ten-fold diminution in the number of living Typhoid bacilli was found and substantiated by subsequent testings.

(10.) *Experiment E.*—Initial number of B. typhosus=10 per c.c. 10 days after the inoculation process the number was reduced to 1 per c.c.

12 days after the inoculation process no Typhoid bacilli were present in 1 c.c, but positive results were obtained with 10 c.c. cultures.

No Typhoid bacilli were present in 10 c.c. of water on the 15th day after inoculation, a result which was confirmed by the negative results of subsequent testings with a like volume of water made on the 18th, 20th, 21st, 22nd, 23rd, and 24th days after inoculation. These final tests emptied the bottle.

(11.) *Experiment B.*—Initial number of B. typhosus=10,000 per c.c.

On the 18th, 22nd, 26th, and 27th days after the inoculation process the numbers had fallen to 100 per c.c., 10 per c.c., 1 per c.c., none in 1 c.c. but present in 10 c.c. respectively. Tests made on the 29th, 30th, 31st, and 32nd days with 10 c.c. of water gave no growth.

(12.) *Experiment D.*—Initial number of B. typhosus=100 per c.c.

On the 15th, 18th, and 20th days after the inoculation process the numbers had fallen to 10 per c.c., 1 per c.c., none in 1 c.c., but present in 10 c.c. respectively.

Tests made on the 30th and 31st days with 10 c.c. of water gave no growth.

In summary at this stage it may be said that in experiments E, B, and D the typhoid bacillus was not present in 10 c.c. of water 15, 29, and 30 days respectively after the inoculation process.

Experiment A.—Initial number of B. typhosus=100,000 per c.c

On the 18th, 26th, 33rd, and 35th days after the inoculation process the numbers had fallen to 10,000 per c.c., 1,000 per c.c., 100 per c.c., and 10 per c.c. respectively. On the 39th day the number was still found to be 10 per c.c.*

Experiment C.—Initial number of B. typhosus=1,000 per c.c.

On the 18th and 33rd days after the inoculation process the number had fallen to 100 per c.c. and 10 per c.c. respectively. On the 39th day the number was still found to be 10 per c.c.†

A. C. HOUSTON.
M. H. GORDON.

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* Final Note, May 4th, 1907. On the 41st day living typhoid bacilli were found in 1 c.c. but not in 0·1 c.c. On the 42nd day a positive result was obtained with 10 c.c but not 1 c.c. of water. The result was *negative* with 10 c.c. of water on the 48th and 50th days after the inoculation process.

† Final Note, May 4th, 1907. On the 41st, 47th, and 50th days *negative* results were obtained with 0·1 c.c, 1 c.c., and 10 c.c. of water, respectively.

TABLE I.

Temperature of Dark Cupboard in which the Bottles A, B, C, D, E were kept.

	Degrees Fahrenheit.			Degrees Fahrenheit.			Degrees Fahrenheit.	
	Max	Min		Max	Min		Max.	Min.
March 24, ...	58	56	April 3, ...	68	58	April 13, ...	63	57
„ 25, ...	59	54	„ 4, ...	68	60	„ 14, ...	60	56
„ 26, ...	64	56	„ 5, ...	66	60	„ 15, ...	58	55
„ 27, ...	65	57	„ 6, ...	68	59	„ 16, ..	64	55
„ 28, ...	63	56	„ 7, ...	64	57	„ 17, ...	65	55
„ 29, ...	63	57	„ 8, ...	58	55	„ 18, ...	64	55
„ 30, ...	60	59	„ 9, ...	63	57	„ 19, ...	63	55
„ 31, ...	61	59	„ 10, ...	61	56	„ 20, ...	63	55
April 1, ...	60	59	„ 11, ...	67	56	„ 21, ...	57	56
„ 2, ...	60	57	„ 12, ...	64	56	„ 22, ...	56	55

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